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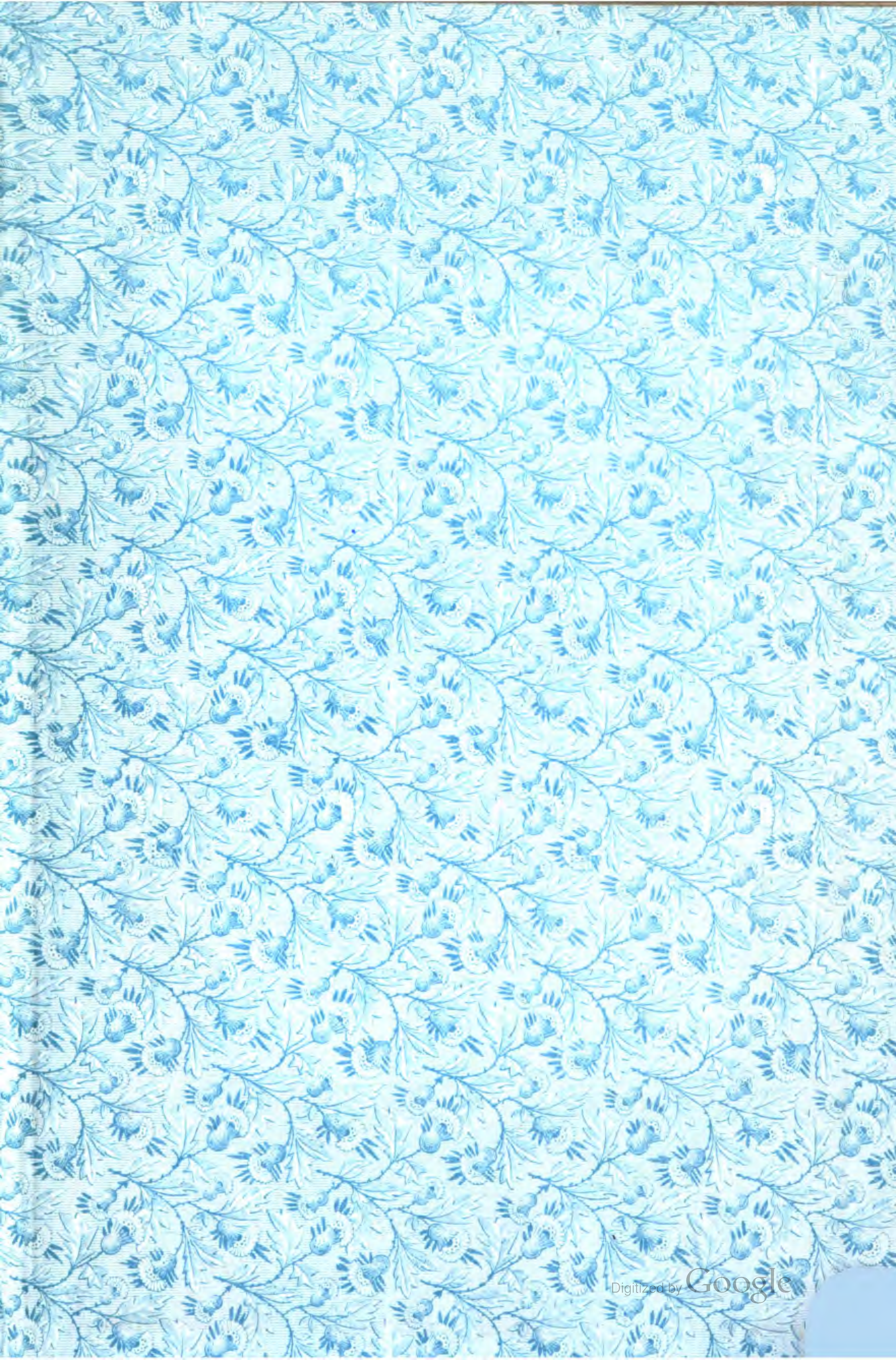

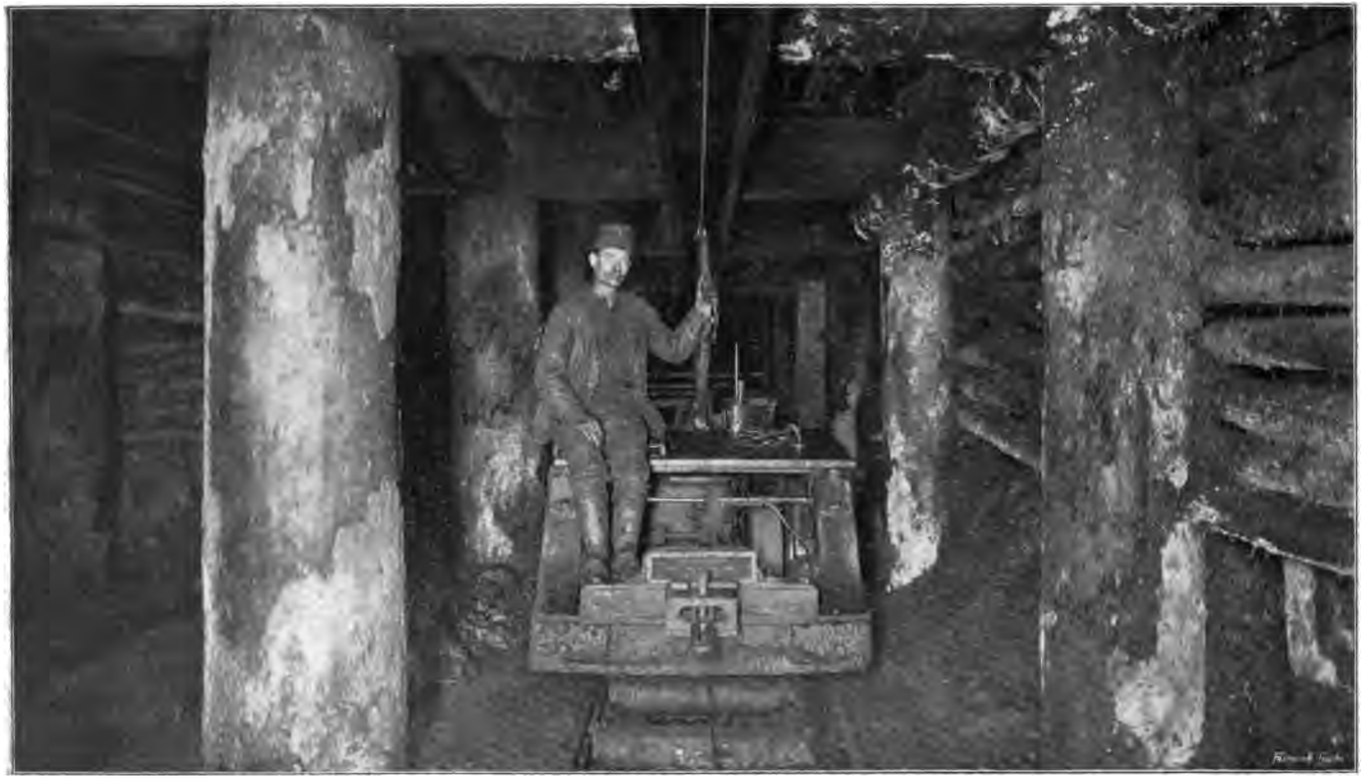

EAST END MINE, PITTSBURG AND LAKE ANGELINE IRON MINING CO., MICHIGAN, MAY 1894.
VIEW OF THE FIRST ELECTRIC MOTOR USED UNDERGROUND IN THE LAKE SUPERIOR REGION.

PROCEEDINGS

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OF THE

LAKE SUPERIOR MINING INSTITUTE

THIRD ANNUAL MEETING

C MARCH, 1895

VOL. III

PUBLISHED BY THE INSTITUTE

PRINTED AND BOUND BY
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LANSING, - MICH.

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Williams, W. H., Beacon, Mich.
Winchell, Horace V., Minneapolis, Minn.
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RULES OF THE INSTITUTE.

I.

OBJECTS.

The objects of the Lake Superior Mining Institute are, to promote the arts and sciences connected with the economical production of the useful minerals and metals in the Lake Superior region, and the welfare of those employed in these industries, by means of meetings for social intercourse, by excursions, and by the reading and discussion of practical and professional papers, and to circulate, by means of publications among its members, the information thus obtained.

II.

MEMBERSHIP.

Any person interested in the objects of the institute is eligible for membership.

Honorary members, not exceeding ten in number, may be admitted to all the privileges of regular members except to vote. They must be persons eminent in mining or sciences relating thereto.

III.

ELECTION OF MEMBERS.

Each person desirous of becoming a member shall be proposed by at least three members, approved by the council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the council may prescribe) upon receiving three-fourths of the votes cast. He shall become a member on the payment of his first annual dues, within ninety days of the notification of his election.

Each person proposed as an honorary member shall be recommended by at least ten members, approved by the council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the council may prescribe), on receiving nine-tenths of the votes cast.

IV.

WITHDRAWAL FROM MEMBERSHIP.

Upon the recommendation of the council, any member may be stricken from the list and denied the privilege of membership, by the vote of three-fourths of the members present at any regular meeting, due notice having been mailed in writing by the secretary to him.

V.

DUES.

The dues of members shall be five dollars, payable upon their election, and five dollars per annum thereafter, payable in advance at or before the annual meeting. Honorary members shall not be liable to dues. Any member not in arrears may become a life member by the payment of fifty dollars at one time, and shall not be liable thereafter to annual dues. Any member in arrears may, at the discretion of the council, be deprived of the receipt of publications or be stricken from the list of members when in arrears six months; PROVIDED, that he may be restored to membership by the council on the payment of all arrears, or by reelection after an interval of three years.

VI.

OFFICERS.

There shall be a president, five vice-presidents, five managers, a secretary and a treasurer, and these officers shall constitute the council.

VII.

TERM OF OFFICE.

The president, secretary and treasurer shall be elected for one year and the vice-presidents and managers for two years. except that at the first election two vice-presidents and three managers shall be elected for only one year. No president, vice-president or manager shall be eligible for immediate reelection to the same office at the expiration of the term for which he was elected. The term of office shall continue until the adjournment of the meeting at which their successors are elected.

Vacancies in the council, whether by death, resignation, or the failure for one year to attend the council meetings, or to perform the duties of the office, shall be filled by the appointment of the council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; PROVIDED, that such appointment shall not render him ineligible at the next election.

VIII.

DUTIES OF OFFICERS.

All the affairs of the institute shall be managed by the council, except the selection of the place of holding regular meetings.

The duties of all officers shall be such as usually pertain to their offices, or may be delegated to them by the council.

The council may in its discretion require bonds to be given by the treasurer, and may allow the secretary such compensation for his services as they deem proper.

At each annual meeting the council shall make a report of proceedings to the Institute, together with a financial statement.

Five members of the council shall constitute a quorum; but the council may appoint an executive committee, or business may be transacted at a regularly called meeting of the council, at which less than a quorum is present, subject to the approval of a majority of the council, subsequently given in writing to the secretary and recorded by him with the minutes.

There shall be a meeting of the council at every regular meeting of the Institute, and at such other times as they determine.

IX.

ELECTION OF OFFICERS.

Any five members, not in arrears, may nominate and present to the secretary over their signatures, at least thirty days before the annual meeting, the names of such candidates as they may select for offices falling under the rules. The council, or a committee thereof duly authorized for the purpose, may also make similar nominations. The assent of the nominees shall have been secured in all cases.

Not less than two weeks prior to the annual meeting, the secretary shall mail to all members not in arrears a list of all nominations made, and the number of officers to be voted for in the form of a letter ballot. Each member may vote either by striking from or adding to the names upon the list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing the ballot with his name, and either mailing it to the secretary, or presenting it in person at the annual meeting.

In case nominations are not made thirty days prior to the date of the annual meeting for all the offices becoming vacant under the rules, nominations for such offices may be made at the said meeting by five members not in arrears, and an election held by written or printed ballot.

The ballots in either case shall be received and examined by three tellers appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected. The ballots shall be destroyed, and a list of the elected officers, certified by the tellers, shall be preserved by the secretary.

X.

MEETINGS.

The annual meeting of the Institute shall be held on the third Tuesday of August in each year commencing in 1896. The Institute may at a regular meeting select the place for holding the next regular meeting. If no place is selected by the Institute it shall be done by the council.

Special meetings may be called whenever the council may see fit; and the secretary shall call a special meeting at the written request of twenty or more members. No other business shall be transacted at a special meeting than that for which it was called.

Notices of all meetings shall be mailed to all members, at least thirty days in advance, with a statement of the business to be transacted, papers to be read, topics for discussion and excursions proposed.

No vote shall be taken at any meeting on any question not pertaining to the business of conducting the Institute.

Every question that shall properly come before any meeting of the Institute, shall be decided, unless otherwise provided for in these rules, by the votes of a majority of the members then present.

Any member may introduce a stranger to any regular meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

XI.

PAPERS AND PUBLICATIONS.

Any member may read a paper at any regular meeting of the Institute, provided the same shall have been submitted to and approved by the council, or a committee duly authorized by it for that purpose prior to such meeting. All papers shall become the property of the institute on their acceptance, and with the discussion thereon, shall subsequently be published for distribution. The number, form and distribution of all publications shall be under the control of the council.

The Institute is not, as a body, responsible for the statements of facts or opinion advanced in papers or discussions at its meetings, and it is understood, that papers and discussions should not include personalities, or matters relating to politics, or purely to trade.

XII.

AMENDMENTS.

These rules may be amended by a two-thirds vote taken by letter ballot in the same manner as is provided for the election of officers by letter ballot, PROVIDED, that written notice of the proposed amendment shall have been given at a previous meeting.

PROCEEDINGS OF THE THIRD ANNUAL MEETING.

Wednesday, March 6. 1895.

Members and guests assembled at Duluth on Wednesday morning, March 6. A special train, composed of two sleeping cars and two private cars, the last having been put at the service of the Institute by the Duluth, Mesaba & Northern and the Duluth & Iron Range railroads, left Duluth at 11 A. M. and conveyed the party to the Mountain Iron Mine.

Lunch was served on the train.

At the request of the Secretary, Mr. H. V. Winchell had kindly prepared and had printed in pamphlet form, a condensed account of the mining operations on the iron ranges of Minnesota. This guide, with its accompanying map, was distributed on leaving Duluth and was of great value, being highly appreciated by the visitors. In addition, the Geological and Natural History Survey of Minnesota presented each member of the party with a copy of its report upon the Mesaba Range, which, with the guide, furnished a pleasant and profitable means of passing away the time while traveling from point to point.

After inspecting the Mountain Iron property the next stop was made at the Auburn mine.

From the Auburn, the train carried the party to Virginia, where the remainder of the afternoon was occupied in visiting the Oliver mine and others in the vicinity.

After supper an evening session of the Institute was held in Crockett's Hall, Virginia.

The meeting was called to order by the President, Mr. J. Parke Channing, who opened the meeting with an address, taking for his subject, "Accidents in Mines."

The President's address was followed by the reading of a paper by Mr. E. F. Brown upon "The Distribution of Phosphorus and System of Sampling at the Pewabic Mine, Michigan."

After the discussion of this paper Mr. F. F. Sharpless made a few remarks upon the discrepancies that often occur in the analyses of iron ore made by different chemists.

Mr. Sharpless attributed these discrepancies to lack of uniformity in methods of sampling and analyzing, and suggested that a committee be appointed to investigate the subject.

This suggestion was then discussed as follows:

MR. W. J. OLCOTT—Our experience on this range for the past year does not seem to bear out some of the discrepancies that Mr. Sharpless refers to. I would call attention to the comparative analyses of some of the ore shipments of the Mountain iron mine as made by our chemist at Mountain Iron and by the Cleveland chemist. The variation for the entire season does not show over .003 in phosphorus.

MR. J. PARKE CHANNING—I might say that I had a case once where I had a lot of ore reported .070 in phosphorus when the mine samples showed .045 phos. The difference was explained by impure chemicals. A friend of mine told me that he was once in an office in Cleveland when he saw a gentleman come into that office with two cargo samples, *one in each pocket.* I think that certainly shows that in some cases the sampling has been neglected but in Mr. Olcott's case I think that much more care had been taken at both ends of the line.

MR. WILLIAM KELLY—The subject suggested is certainly one that ought to be pursued, and our chemists ought to have a uniform method, but I rise to question our authority at any meeting to act for the Lake Superior Mining Institute in this manner, or in any similar manner. The object of our institute, as I understand it, is for the purpose of holding meetings where papers may be read and discussed, and we are prevented by the express wording of our constitution from taking any vote on any subject except in regard to the conducting of the meeting, and we are not responsible for the individual opinion of different men, and the reasons for our not taking action on such questions, are, I think, quite plain. There are two. One is that this meeting is not a representative meeting of the Institue in any sense. We are not sent here and do not come here with the question that has been suggested, and we are in no wise authorized by those who are not here to act for them, and it would be improper to bind them at the same time that we bind ourselves by any action of this kind. The other point is, that if we enter into this work, while the object is undoubtedly commendable, we cannot tell what the next proposition may be and we will have no place where we can draw any line, and we may be led into a series of announcements that may lead to the breaking up of the Institute, and therefore I think we should avoid any action of this kind.

The subject was dropped without any action being taken.

Mr. Per Larsson then read a paper upon "The Efficiencies of Some Pumping Plants on the Menominee Range, Michigan." After a discussion of Mr. Larsson's paper the meeting closed with the appointment of nominating and auditing committees as follows:

Nominating Committee—Messrs. E. F. Brown, G. H. Abeel, W. Fitch, Graham Pope, Geo. Wallace, N. P. Hulst.

Auditing Committee—Messrs. F. P. Mills and S. T. Beattie.

March 7th.

After an early breakfast at Virginia the party resumed its tour along the Mesabi Range, making the next stop at Biwabik, where the Biwabik and Canton properties were visited.

At Biwabik the train was transferred to the tracks of the Duluth and Iron Range railroad and hauled direct to Tower, where dinner was served at the Vermilion Hotel.

Dinner over, the train carried the party to Soudan, where the afternoon was spent viewing the works of the Minnesota mine. Many of the members accepted an invitation to go underground.

In the evening the second business session was held in the Tower Opera House, at which the following papers were read and discussed: "The Relation of the Vein at the Central Mine, Keweenaw Point, to the Kearsarge Conglomerate," by Dr. L. L. Hubbard; "The Hoisting Plant of the Lake Mine, Cleveland Iron Mining Company," by Mr. J. M. Vickers; "Open-Pit Mining," by Mr. F. W. Denton.

The secretary then read a communication upon the subject of crushing the hard hematites, which is published on another page.

The committee reports having been called for, the nominating committee reported as follows:

President—John Duncan.

Vice-Presidents — F. McM. Stanton, Geo. A. Newett, Per Larsson.

Managers—F. P. Mills, Edwin Ball.

Treasurer—Geo. D. Swift.

Secretary—F. W. Denton.

The candidates of the nominating committee were unanimously elected.

After a short recess the council reported its approval of the following list of candidates for membership:

Wm. R. Appleby,
C. E. Bailey,
R. M. Bennett,
Wm. C. Brown.
R. C. Browning,
Arthur E. Buzzo,
N. J. Cavanaugh,
James Cocking,
J. G. Cohoe,
H. B. Crowl,
Wm. E. Dickinson,
F. A. Emmerton,
H. D. Fisher,
H. W. Fesing,
A. J. Findley,
G. B. Frankforder,
E. J. Gilbert.
J. D. Gilchrist,
G. S. Gordon,
U. S. Grant,
C. W. Hall,
Jacob Hauserman,
W. L. Honnold,
James Hosking,
John H. Karkeet,
E. A. Knight,
B. E. LaLonde,
C. D. Lawton,
Fred Lerch,
C. T. Mixer,
H. F. Nickerson,
Geo. A. Newett,
H. R. Paine,
Frank E. Pearse,
S. P. Snider,
S. A. Hjalmar Sjorgren,
F. W. Sperr,
J. A. Van Mater,
W. H. Williams,
C. D. Wilkinson,
A. J. Yungbluth.

These candidates were duly elected.

Mr. N. H. Winchell was then unanimously elected an honorary member of the Institute.

The Council announced the following resolution:

Resolved, That it is the sense of the Council that Article X of the Constitution be amended so as to read as follows: The annual meeting of the Institute shall be held on the third Tuesday of August in each year, commencing in 1896.*

Suitable motions were passed thanking the various mining companies and the two railroads for their many courtesies.

The Institute is deeply indebted to the Duluth & Iron Range and the Duluth, Mesaba & Northern railway companies for the success of the meeting.

Both roads furnished free transportation in special trains, making possible a comfortable and harmonious excursion over many miles of territory in the depths of a severe winter.

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*The change recommended by the Council has been submitted to letter ballot and carried.

FINANCIAL STATEMENT.

Receipts.

Dues from members	$455 00	
From sale of extra copies of Vol. II	19.89	
Total receipts	$474.89	$474.89
Balance 1893–94		225.10
		$699.99

Expenditures.

Expenses 2d annual meeting	$ 41.50	
PRINTING AND STATIONERY.		
Envelopes, circulars, vouchers, etc.	20.05	
1,000 copies of Vol. II, including cost of plates, freight and express	412.83	
Postage and minor expenses	34.67	
Secretary's salary	100 00	
	$609 05	$609.05
Balance in treasury		90.94

REGISTRY OF MEMBERS AND GUESTS IN ATTENDANCE AT THE THIRD ANNUAL MEETING.

G. A. Alvar,
Edwin Ball,
Geo. H. Abeel,
S. T. Beattie,
J. F. Armstrong,
Wm. Bond,
C. M. Boss,
E. F. Brown,
J. Parke Channing,
F. Copeland,
F. L. Coventry,
W. W. J. Croze,
R. C. Knight,
A. C. Lane,
Per Larsson,
J. B. Lyon,
James MacNaughton,
F. P. Mills.
C. H. Munger,
W. J. Olcott,
J. Orrison,
H. B. Paull,
Graham Pope,
A. E. Seaman,
R. C. Browning,
H. W. Fesing,
H. D. Fisher,
James Hosking,
James Cocking,
W. R. Appleby,
Geo. Naylor,
Wm. Trestrail,
C. A. Lawton,
A. E. Buzzo,
A. H. Hedderro,
B. E. LaLonde,

R. H. Channing,
J. W. Curnow,
F. W. Denton,
W. H. Downing,
Theo. Dengler,
Walter Fitch,
B. W. Goodsell,
C. E. Hendrick,
L. L. Hubbard,
Nelson P. Hulst,
Wm. Kelly,
F. F. Sharpless,
C. S. Simpson,
Geo. D. Swift,
G. C. Trevarthan,
Wm. D. VanDyke,
J. M. Vickers,
H. V. Winchell,
D. H. Bacon,
Geo. Wallace,
W. H. Williams,
Geo. A. Newett,
C. T. Mixer,
A. J. Yungbluth,
C. D. Wilkinson,
G. B. Frankforder,
S. P. Snider,
R. M. Bennett,
A. J. Findley,
F. A. Emmerton,
Wm. C. Brown,
U. S. Grant.

THE IRON RANGES

OF

MINNESOTA.

Prepared for the Third Annual Meeting

OF THE

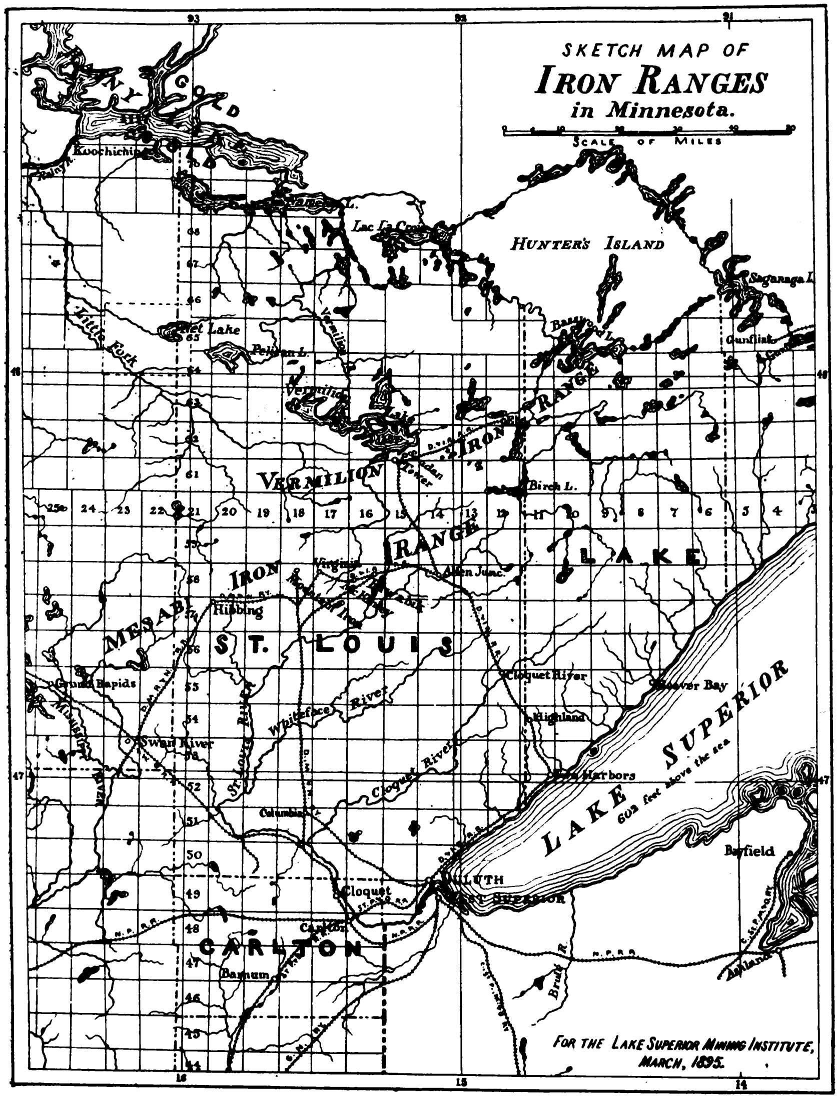
LAKE SUPERIOR MINING INSTITUTE

DULUTH, VIRGINIA, TOWER,

March 6, 7, and 8, 1895.

BY HORACE V. WINCHELL.

PUBLISHED BY THE INSTITUTE.


SKETCH MAP OF
IRON RANGES
in Minnesota.
SCALE OF MILES
0 5 10 20 30 40 50
93
92
91
16
15
14
48
47
RAINY GOLD
Koochiching
Rainy R.
Lac La Croix
HUNTER'S ISLAND
Saganaga L.
Gunflint
Basswood L.
Net Lake
Pelican L.
Vermilion R.
Little Fork
Vermilion Lake
VERMILION IRON RANGE
Tower
Ely
Birch L.
25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4
68 67 66 65 64 63 62 61 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45 44
MESABI IRON RANGE
Virginia
Hibbing
Allen Junc.
LAKE
ST. LOUIS
Grand Rapids
Swan River
Mississippi
St. Louis River
Whiteface River
Cloquet River
Cloquet River
Beaver Bay
Highland
Two Harbors
LAKE SUPERIOR
602 feet above the sea
Columbia
Cloquet
Carlton
CARLTON
Barnum
DULUTH
WEST SUPERIOR
Bayfield
Ashland
Brulé R.
N. P. R. R.
D. M. & N. R. R.
D. & I. R. R. R.
St. P. & D. R. R.
FOR THE LAKE SUPERIOR MINING INSTITUTE,
MARCH, 1895.

THE IRON RANGES OF MINNESOTA.

I. MESABI RANGE.*

The discovery of ore in merchantable quantity and quality on this range was first made in 1891 and 1892, and for that reason it has not produced so much ore nor has it become so well known to the world as the Vermilion Range, yet it is first mentioned here because of its greater novelty and interest, and because it is the first to be visited. Situated about sixty miles in a direct line northwest of and roughly parallel with the north shore of lake Superior at an altitude of from 1200-1550 feet above the lake is a ridge of Archean syenite and granite, flanked on both sides by crystalline and semi-crystalline schists. This ridge has been called the Giant's Range. Following closely along the south side of this Giant's Range, lying at times nearly up to its summit, are the outcropping edges of younger strata which lie unconformably upon the syenite and schists. These later strata are of the age of the Taconic or Upper Huronian. They are in turn covered on their south slope, over a portion of their extent, by eruptive rocks of Keweenawan age or by still more recent Cretaceous sediments. To this latter range of rocks, in early days to the gabbro of the Keweenawan and later to the iron ore belt, has for many years been given the name Mesabi range.†

The iron ore deposits of the Mesabi consist of beds of soft hematite lying at low angles from horizontal, and usually covered merely by glacial drift. These deposits are often of remarkable extent and depth, and are noteworthy examples of the extent to which ordinary atmospheric oxidizing agencies under favorable conditions can affect a re-arrangement and concentration of the component parts of solid rocks. The genesis and geology of the ores and rocks of this range are fully discussed in **J. E. Spurr's** Bulletin on the Iron Bearing Rocks of the Mesabi Range.

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*Having been entirely prepared and printed in less than one week, many items of detailed information were necessarily omitted.

†The name is taken from the Chippewa language, and has reference to a fabulous giant who is supposed to have made his home in these hills. This spelling of the name "Mesabi" is adopted because it conforms with the usage of the state and national geological surveys for many years, and is in accord with the decision of the National Board of Geographic Names established by Congress to decide such questions.

Railroads were not constructed to these mines until the fall of 1892. As shown by the map, there are now three roads running to the iron mines on the Mesabi. Only two of them, the Duluth and Iron Range and Duluth, Missabe and Northern, have hauled any ore. The Duluth, Mississippi River and Northern, in conjunction with the Duluth and Winnipeg, will haul its first ore the coming season.

The D. & I. R. R. was built from Two Harbors to the Vermilion range at Tower, a distance of 67.6 miles, in 1884, and extended to Ely, 21 miles east of Tower, in 1888. It was built in to Duluth in 1886, and branches were extended from its main line to the Mesabi mines in 1892 and 1893. The grades on this road are very steep going north, and in the 13 miles from Two Harbors to Highland there is a rise of 1,050 feet. The mogul locomotives used on ore trains are among the largest ever made. The D. & I. R. R. company is closely affiliated with the Minnesota Iron company, which owns many mines on both ranges, from which in 1894 were produced and shipped more than 1,300,000 tons of ore. Owning its own docks at Two Harbors and a fleet of eight steel steamers to transport the ore to Lake Erie, this company is well equipped for the transaction of a large amount of business.

The D. M. & N. Ry. was constructed from Stony Brook Junction, on the D. & W. R. R., to the mines on the Mesabi in 1892 and 1893. Built through the efforts of the **Merritt Brothers, Chase Brothers** and **Donald Grant,** it passed in 1893 into the hands of the Lake Superior Consolidated Iron Mines, in which company the chief stockholder is **Jno. D. Rockefeller.** This corporation also owns a number of mines on the Mesabi and its own docks at Duluth. Its output in 1894 was nearly 600,000 tons of ore from its own mines. In this season the D., M. & N. Ry. carried more than 1,300,000 tons of ore to Lake Superior. The ore rate to the lake from all Mesabi mines is eighty cents per gross ton.

The D. M. R. & N. was primarily intended to be a logging road, built by Michigan lumbermen; but the discovery of iron ore on lands belonging to these same parties and on adjacent tracts induced them to construct it standard gauge and of heavy rails, suitable for ore transportation. It is tributary to the D. & W. R. R., which has ore docks at Superior. The Mahoning mine at Hibbing will ship over this road, as will other mines further west when more fully developed.

HIBBING GROUP OF MINES.

Beginning at the westernmost developed properties we shall describe the mines of the Mesabi in order of occurrence eastward. **Hibbing** is located in the N. W. 1-4 Section 6, T. 57, R. 20 W. It is the present terminus of the D. M. & N. and D. M. R. & N. railroads. Surrounded by a large amount of pine timber, and adjacent to large deposits of iron ore it is a town of great promise.

Lake Superior Mine

Situated on the S. W. 1-4 S. W. 1-4, Sec. 31, T. 58, R. 20 W. It was discovered in 1892 by Capt. **T. W. Nelson** working under the direction of Mr. **Frank Hibbing**, of Duluth. No ore has been produced from this mine as yet. It is being developed for underground mining under the direction of Mr. **W. J. Olcott** for the Lake Superior Consolidated Company who are operating it at present. The superintendent is Mr. **P. Mitchell.** It will probably be on the list of shippers for 1895. It is operated on a 30 cent lease and the profits are divided between the Consolidated and the Lake Superior companies.

Mahoning Mine.

After the discovery of ore in the N. E. 1-4 Sec. 3, 57-21, the Mahoning Company, last year, developed one of the largest ore bodies on the range in the north half of sections 1 and 2, 57-21. This ore is now being uncovered or "stripped" to prepare for shipments in 1895. The work is under the direction of Mr. **W. C. Agnew.** The fee to this land belongs to Saginaw lumbermen, the Mahoning company holding a lease.

Sellers Mine.

This mine is situated just north and northeast of Hibbing.

Shafts are being sunk and development work done as rapidly as possible.

It is understood that this mine, like others in the Hibbing group, has an unpleasant amount of water to contend with. Mr. **Chas. Munger** is in charge of operations here.

West of Hibbing.

Before leaving the Hibbing group it should be stated that other mines are being developed still farther west in townships 57-21 and 57-22, where some large deposits have been discovered by the explorations of Messrs. **E. J. Longyear, R. M. Bennett, F. Hibbing and Jno. Mallmann.**

MOUNTAIN IRON GROUP OF MINES.

This group of mines is situated about twenty miles east and north of the Hibbing group, and although the iron formation is continuous between the two groups of mines, there have been but two ore deposits discovered as yet in all that distance. This is an example of the large amount of unexplored territory which remains on the Mesabi.

Mountain Iron Mine.

This was the first ore deposit discovered on the Mesabi range, and its discovery was not followed by another for nearly a year. Indeed, in the light of subsequent discoveries the little basin of low grade ore found by Capt. **J. A. Nichols,** at the north end of the Mountain Iron deposit seems insignificant to a degree. It is not now considered worth mining; but it was looked upon as a bonanza in the early part of 1892, and thus furnished the incentive to further explorations and the discovery of better ore at this and other points along the range. It was on the strength of this discovery that the D. M. and N. Ry. was projected by the Messrs. Merritt and Chase, the owners of the mine at that time.

This mine is owned in fee by the Lake Superior Consolidated Iron Mines. It is worked by the open cut method, the ore and overburden being loaded directly into cars by steam shovels. The early development of this mine was in the hands of Capt. **A. P. Wood** and later Capt. **J. G. Cohoe.** Its record for the first three years has not been equaled in the annals of iron mining, its product having been as follows:

1892	4,245	tons.
1893	119,818	"
1894	573,440	"
Total	697,503	"

In reality this product is that of the first two full years only. In the total for 1894 is included the product of the **Rathbun,** located on the same deposit and operated by the same company, but not owned entirely in fee. The superintendent is Mr. **Jno. Gilchrist.** These mines are in the N. W. 1-4 Sec. 3, T. 58, R. 18. Other lands in this locality are known to contain ore; but have not yet been exploited.

VIRGINIA GROUP OF MINES.

This is by far the largest group on the range. North, east and south of the city of Virginia are found the valuable deposits, lying on the slopes of the elevated ridge of Archean schist. Situated on a couple of small lakes at the foot of this ridge, where stood nothing but a dense and untracked forest in 1892, **Virginia** is the metropolis of the range. Totally annihilated in June, 1893, by a fire which swept away all the possessions of many of her inhabitants and left them without food, shelter or clothing, it has again sprung up in spite of hard times and prospered beyond all expectation. The first pit in ore in this township, 58-17, was sunk on the SE 1-4 NE 1-4 Sec. 8, by Capt. **Cohoe** and discovered ore at the depth of 13 feet. This was in March, 1892, and was the discovery of the

Missabe Mountain Mine.

Situated on indemnity school lands belonging to the State, this mine is operated by the **Oliver Mining Company** on a royalty of 65 cents per ton, of which 25 cents goes to the state treasury and 40 cents to the Lake Superior Consolidated. It is understood, however, that this latter amount was reduced to 25 cents in 1894, in consideration of a very large output. The required minimum output is 400,000 tons per annum. Mined in open cut by steam shovels this mine has also been a record breaker, the first two years' shipments having been:

1893	123,015 tons
1894	505,955 tons
Total	628,970 tons

Including the one cent tax, the income to the state from this mine has amounted to $163,532.20 in two years. This mine has been developed and its wonderful record made under the direction of Capt. **Ed. Florada** and Capt. **A. J. Carlin.** A greater depth of ore has been proven here than at any other point on the Mesabi, a vertical drill hole 320 feet in ore having failed to pass through it. Some idea of the quantity of ore on the new range may be gained by an examination of this mine.

Commodore and Franklin Mines.

These two underground mines are in the NW 1-4 Sec. 9, 58-17. They are owned and operated by Messrs. **J. Corrigan, P. McKinney** and **F. Rockefeller,** under the superintendence of Capt. **John Harris.** Their production has been as follows:

	Commodore.	Franklin.
1893	65,137 tons	46,617 tons
1894		223,399 tons
Total	65,137 tons	270,016 tons

The ore from the Franklin mine has a high reputation among furnace men, being both high in iron and low in phosphorus and quite uniform in grade. The shaft at the Franklin is nearly 200 feet deep, largely owing to the great depth of glacial drift at this point.

Norman Mine.

Operated by a sub-corporation of the Minnesota Iron Company. This mine was the second to adopt the "milling" method of mining, viz., to strip off the overburden and mill the ore down through a winze into cars in the mine from which the ore is dumped into skips and hoisted. The location of this mine is the NE 1-4 SW 1-4, Sec. 9, 58-17. The royalty is 25 cents and the output in 1894 was 39,008 tons. The fee is owned by the Rouchleau-Ray Company. The superintendent is Capt. **John Armstrong.**

Ohio Mine.

This mine, although the second to be discovered in the township, has not yet produced any ore. It comprises the W 1-2 SW 1-4, Sec. 9, 58-17, and is part of the Missabe Mountain deposit. Leases and sub-leases have been made and forfeited upon this property, and its exact status at present is unknown to the writer.

Lone Jack Mine.

This is also part of the Missabe Mountain or Oliver deposit and adjoins the Ohio on the north. It consists of the SW 1-4 NW 1-4, Sec. 9. Two inclined shafts were sunk preparatory to mining by Capt. **"Jim" Foley**, but no ore has yet been mined. Further work of exploration is now being conducted here by the Missabe Mountain Company under an option to purchase the fee. Other mines in this group, like the Shaw and Moose, or Virginia, in Sec. 8, and the Alpena and Sauntry in Sec. 5, have not yet been developed extensively. On some of them, as on the Moose, high grade manganese ore has been found in some considerable quantity.

Those interested in the origin of iron ores will find a good example of the transition from taconyte to ore in a railroad cut on the north end of the Moose, near the Missabe Mountain line.

Minnewas Mine.

This mine is on State land, Sec. 16, 58-17. It was developed as an underground mine by Capt. **Cohoe** and Capt. **Phil. Scadden**, and shipped 13,858 tons of ore in 1893. The ore is of excellent quality and the mine is in condition to make a large production. It produced only 2,140 tons in 1894.

Auburn Mine.

This is classed for convenience with the Virginia group, although it is two miles away and probably a separate deposit from those just east of the city. Situated in the north half of Sec. 20, 58-17, the Auburn has one of the finest plants and locations on the range. Operated on a 30-cent lease by the Minnesota Iron Company under the direction of Capt. **Geo. W. Wallace**, it is an example of the best results that can be obtained from the milling process. The output of this mine in 1894 was 110,809 tons.

EVELETH GROUP OF MINES.

Eveleth is situated on the W 1-2 S E 1-4, Sec. 31, 58-17. Near it are many ore deposits, from only one of which (the **Vega**) ore has been marketed. The influence of elevation and favorable situation on the origin of the ore deposits is strikingly illustrated in the occurrence of ore in this locality five or six miles *south* of the ore beds near Virginia, while the general trend of the rocks of the range is but a little north of east and south of west. The tongue of Archean schists which extends from the Giant's Range in a southwesterly course through T. 58-17 elevated the taconyte and slates, and furnished the proper conditions for the formation of the ore deposits.

Adams Mine.

This property is being developed by the Consolidated Company. The mine is in the north half of Sec. 31, 58-17. It is operated on a lease from Chicago and Michigan lumbermen who own the fee. This deposit of ore is supposed to be one of the largest on the Mesabi range, and to contain ore of more than average value because of its granular and shaly nature. The shape of the deposit is irregular and like many others on this new range, its dimensions and exact character have not yet been fully determined. It is being stripped at present. Ore was discovered here by **Neil McInnis** and **D. T. Adams,** of Duluth, in 1893. The Superintendent is Mr. **Geo. Hearding.**

Vega Mine.

West of the Adams is the Vega, lying under too great a burden of glacial till to permit of open cut mining. It produced 5,628 tons of ore in 1894, and is under the direction of Mr. **Geo. St. Clair.**

Fayal Mine.

This is one of the recent acquisitions of the Minnesota Iron Company. It is located in Section 5, 57-17, and was first discovered in 1894. Other properties in this vicinity and in Section 34, 58-17, are known to contain more or less ore, but are not being developed very rapidly at present. This mine is also under the direction of Capt. **Wallace,** Assistant General Manager of the Minnesota Iron Company.

McKINLEY GROUP.

In Section 8, 58-16, ore was discovered by **Duncan McKinley** in December, 1891, and a good deposit has been proven up by rather spasmodic development. No ore has been produced although shafts were sunk, levels run, hoisting plant and pumps installed and everything made ready in 1893. There is litigation over the property at present which may delay its further development indefinitely. The ore extends on to adjoining properties, and has been found by test pits on the Shannon property in Section 18, 58-16. This is another example of undeveloped resources on the Mesabi. The McKinley mine is at present in the charge of Capt. **H. Roberts.**

BIWABIK GROUP.

Great interest attaches to this group because it was the second locality where iron ore was found on the Mesabi. It was, moreover, the scene of the greatest amount of development work in 1892, and took the initiative in both the stripping-and-steam-shovel and stripping-and-milling methods of mining. The existence of high grade soft ore on the Mesabi was demonstrated here earlier and more thoroughly than at any other point on the range, and the quality of the ore shipped from here has not been excelled by any. Failure attended the efforts of the projectors of both new systems of mining,—a fact which does not in the least lessen their interest nor detract from their value and merit.

Biwabik Mine.

The Biwabik mine was first opened up in August, 1891, by Capt. **J. A. Nichols**, who also found the Mountain Iron deposit, and who may well be styled the father of Mesabi mining. Mr. **Wilbur Merritt** was in actual charge at the time ore was first discovered. In April, 1892, the Biwabik Mountain Iron company leased the E½, NE¼ Sec. 3 and the NW¼, NW¼ Sec. 2, 58-16 to **P. L. Kimberly** and associates, who formed the Biwabik Ore company. The royalty was 50 cents per ton on a minimum output of 300,000 tons per annum. A large amount of money was expended in explorations, under the direction of Mr. **J. T. Jones,** and the steam shovel method of stripping and mining was adopted. An electric light plant was provided, locomotives and tracks purchased and a large amount of work done. The severe winter of 1892–3 and the financial stringency combined to defeat all estimates and plans; and a smaller quantity of ore was marketed in 1893 than was hoped for, although the output made broke all records for the first years' shipment.

The **Biwabik Bessemer Company** took possession in 1894 and made new contracts for mining large amounts of ore. Heavy stripping and various difficulties forced the contractors to assign, and again the output was far below the requirements.

The ore is unsurpassed in quality by any on the range. It is fully as accessible as any and in an enormous body of perfect regularity. Careful estimates of the amount of ore on the property have been made and published, from which it appeared that there was known to be more than twenty million tons of ore on these three "forties." Subsequent explorations increased this about twenty per cent. The average depth of overburden is about 30 feet, and the average thickness of the ore about 75 feet. The ore body is half a mile long on this property, nearly one-quarter of a mile wide and shaped like a wedge, with its sharp edge at the north and its thick edge at the south with a thickness of over 100 feet. The output of this mine was as follows:

1893	151,500 tons
1894	90,048 tons
Total	241,548 tons

The first lease at a 30 cent royalty is now owned by the Lake Superior Consolidated Iron Mines, and any forfeiture of the sublease would give this company what is in many respects the most desirable mine on the Mesabi. In order to come out even on the royalty paid and payable this year there must be a production of 658,452 tons in 1895.

Berringer Mine.

Lying close alongside the Biwabik and part of it originally, is the Berringer forty, the NW¼ NE¼, Sec. 3, 58-16. In 1893 there were mined 37,626 tons of excellent ore from this land. In 1894 it was idle, another wreck along the road of large minimums. It was leased to the **Duluth Ore Company** at a 50-cent royalty and 100,000 tons annual minimum output. Under the direction of Dr. **J. A. Crowell,** of Iron Mountain, Mich., and Mr. **F. R. Whittlesey,** the system of stripping and milling was here first adopted and put into operation. The year 1893 was filled with failures, and this was one of them. The ore could not be sold. The royalty was payable, nevertheless, and the fine property, together with all that had been put into it, was sacrificed. It is understood to be now in the hands of the Consolidated Company.

Canton Mine.

Still part of the Biwabik deposit, and found as a result of the discovery of the Biwabik, is the Canton mine, in the SW¼ NE¼, Sec. 3, 58-16. Many years ago the Canton Iron Company, a sub-corporation of the Minnesota Iron Company, acquired title to a large tract of lands in 59-16 and the vicinity. This particular tract was among the lot. Had the first selection been one township farther south or southwest they would have included several of the best mines on the Mesabi range.

The Canton is operated as an underground mine by Capt. **John F. Armstrong.** There are two shafts, "A" and "B." Shaft "A" is down to the second level. The mine is worked by rooming and different methods of caving. It has had to contend with all the difficulties of work in a new region, under new conditions and unknown environments, but has faced them all and made a good record. Its shipments have amounted to:

1893	24,416 tons
1894	213,853 tons
Total	238,269 tons

Last year there were 75,000 tons of ore left on the stock piles, and as much more could have been mined had there been a market for the ore.

The Biwabik ore deposit continues across the Canton on to the contiguous **Rouchleau** land on the south, where it has been found by diamond drilling. The surface of the ore has a decided slope to the south, and in the ends of some of the upper levels in the Canton the cemented glacial till may be seen resting on the ore.

Cincinnati Mine.

At the time of the craze in Mesabi iron stocks in Duluth, in 1892, the Cincinnati stock sold at $6.25 per share, on which basis the lease on the mine was worth $750,000. This mine is on the eastern end of the Biwabik deposit, in section 2, 58-16. The ore is rather silicious but quite low in phosphorus. The property was sub-leased in 1892 to Messrs. **F. A. Bates** and **H. P. Barbour,** who organized the Standard Ore Co., and mined 26,372 tons of ore in 1893, at a royalty of 55 cents per ton. No ore was mined in 1894, and part of the property passed back into the hands of the fee owners.

The Archean green schists and the quartzyte which underlies the taconyte or iron-bearing rock are exposed near the north side of the Cincinnati and Biwabik properties.

Hale Mine.

The Hale mine is a mile east of the Cincinnati. It is a narrow body of rather low grade ore, and lies close up against the green schists. Shipments of this ore have been made for the past two years, under the direction of Mr. **A. C. Bates,** mostly to the **Thomas Iron Company,** as follows:

1893	3,616 tons.
1894	24,167 tons.
Total	27,783 tons.

II. VERMILION RANGE.

On the Vermilion range is quite a different set of conditions from those on the Mesabi. Instead of nearly flat deposits of ore we find them nearly vertical. Instead of a layer of ore of limited thickness all over a 40-acre tract, with no hanging-wall to work under, we find steeply inclined lenses of ore confined between walls of schist and extending in a series downward to an indefinite depth. In the place of ore so fine and powdery that it is objected to by the furnace operators, we have here ore so solid and massive that it must be artificially crushed by powerful machines before it can be sold. (At the Chandler the ore has been crushed by nature.) In the place of covered deposits which must be sought for by drill holes and test pits, there were originally bold, bare knobs of hard jasper and hematite projecting in polished peaks and domes a hundred feet above the surrounding, more easily eroded schist. It must be admitted, however, that there is more regularity in the occurrence of the Mesabi ore beds than those of the Vermilion; and more can be told about the probable occurrence of ore in a given locality by a study of the surrounding geology and topography than can be predicted in any way on the Vermilion.

TOWER AND SOUDAN GROUP.

Minnesota Mines.

Discovered thirty years ago or more, no ore was shipped from this range until 1884. The D. & I. R. R. was built by **Charlemagne Tower,** of Philadelphia, who became interested in the project through the efforts of Mr. **Geo. C. Stone.** Capt. **E. Morcom** had charge of the first work of development until the entire group of mines, railroad and state land grants were sold to the present Minnesota Iron Company in 1886. Since then all matters pertaining to the management of the mines have been under the supervision of Mr. **D. H. Bacon.** It is generally admitted that there is not a better planned, better kept and more complete and efficient mining plant in the Lake Superior region. It is in many respects a model of how mining operations ought to be conducted.

The geology of the region immediately surrounding the mines at Soudan and Tower is exceedingly complicated and difficult to understand. It is not yet known whether there is one fold or several, whether there are unconformities of great extent and significance or not, nor in which direction the rocks grow older or younger. The region presents a good field for original investigation.

The iron ore and jasper of the Vermilion range are believed to be chemical oceanic precipitates, dating from the period of the formation of the enclosing rocks. Chemical action resulting from carbonated atmospheric waters, has so acted upon the jaspilyte lenses subsequent to the folding of the sediments as to concentrate the iron in certain portions of these lenses and leave the nearly pure silica in other portions. This process of ore formation through concentration by downward percolating waters is well illustrated at the Chandler mine.

Ore is being hoisted in eight different shafts at the Minnesota mines. These shafts are between 400 and 800 feet deep and have for the most part underground connections with each other. They are sunk in the foot wall and communicate with the ore body by cross cuts at the various levels. The individual lenses are from 300 to 1,000 feet long, and about half as wide or deep with a thickness of from 10 to 90 feet. Their shape and course in the chloritic rocks is extremely irregular. When one lense is exhausted other lenses are usually found at greater depth or on either side by diamond drilling. The present working force numbers between 600 and 700 men.

The filling system is adopted here and the ore is taken out in overhand stopes the full thickness of the ore body. Rock for filling is drawn down from upper levels or blasted down from the walls where the lense is narrow. The levels are about 75 feet apart, and chutes for milling the ore are placed at intervals of 50 feet. This method has proven successful and more economical than the old method of underhand stopes leaving floors of ore to support the walls.

The compressor house is on the shore of Vermilion lake north of the mine.

Ore is loaded from pockets and stockpiles into cars on the railroad tracks which are laid along the south side of the ridge in which the ore is mined. The mines are at present under the direction of Capt. **Edwin Ball.**

The table on page 32 shows the annual production of ore from these mines since 1884.

The quality of Vermilion range hematite has made it famous. "Minnesota No. 1 Bessemer" is as well and favorably known to blast furnace operators as "Minnesota No. 1 Hard" is to grain men. The per cent. of iron is high; but less than half the ore produced from these mines is within the Bessemer limit, as to phosphorus.

Tower is situated about two miles west of Soudan, near Vermilion lake. All of the supplies used by the miners and their families comes from Tower, as no stores are allowed at Soudan. A considerable amount of lumber is sawed at Tower. It is also becoming quite a summer resort and offers many attractions to campers and tourists.

ELY GROUP OF MINES.

Twenty-one miles east of Tower are the only other mines yet developed on the Vermilion range. The first work of exploration was performed on the present site of the Chandler mine in the summer of 1886. Trenches were dug in the mixed ore and gravel which lay above and a little south of the Chandler ore deposit. In 1888 the D. & I. R. R. reached the mine and the town of Ely sprung up. Situated on the rocky hills south of Long lake the town is dependent almost entirely upon the mines and the trade of explorers for its support; although a lumbering industry has recently sprung up in its vicinity.

Chandler Mine.

The ore of the Chandler mine is peculiar in two respects. In the first place, it is hard ore crushed into small bits and pieces by natural forces. In the second place it is all bessemer ore. There are but two grades of ore produced from the Chandler, the "Chandler," guaranteed to carry 63 per cent. iron and 0.05 per cent. phosphorus, and "Long Lake," guaranteed to average 60 per cent. iron and 0.05 phosphorus. The phosphorus really runs with wonderful regularity along at about 0.044 per cent. It is thus easily seen that Chandler ore is a very desirable ore and finds a ready purchaser. It is also a very easy ore to handle in the mine and on stockpile.

The mining is done by the caving system and is performed at a very low cost for underground mining.

There are four shafts, two on the north and two on the south side of the ore deposit. The western shafts are not now used for hoisting ore. The levels are sixty feet apart and the workings are now at the depth of more than 400 feet.

This mine was for several years under the direction of Mr. **Jos. Sellwood,** with Mr. **Jno. Pengilly** as mining captain. For the past three or four years Capt. Pengilly has had the entire management. The record of the annual production is given on page 32.

The Chandler deposit lies in a basin or fold of green schist, which forms a "foot wall" on each side, the north wall sloping south and the south wall sloping north. The axis of the deposit pitches east, and one narrow end of the ore comes to the surface of the ground on the "Lockhart" land just west of the Chandler. Toward the east the ore pitches under a capping of jasper and extends on to the Pioneer property, where it is found at the depth of 400 to 800 feet. The ore body seems to have been subjected to a buckled fold which crushed it and greatly increased the width of its middle portion. A peculiar rotted, rusty zone of red schist lies between the ore and the unaltered green schists. This is called "paint rock" by the miners. This mine has paid a small fortune in royalties to the fee owners, among whom are Hon. **Martin Pattison** of West Superior, and **H. M. Bradley** of Duluth.

Pioneer Mine.

The jasper and iron ore of the Chandler mine, as already stated, pass directly across the Pioneer property. Owing to the great depth at which the ore is found, there has been great difficulty in getting the mine developed. Small shoots of ore have been found running through the jasper above the main ore body; and these have furnished all the ore shipped thus far. During the past two years, however, a four-compartment shaft has been sunk 800 feet and good ore has been found both by drilling and cross-cutting. The prospects are good for as large a deposit of ore here as in the Chandler. The mine superintendent is Capt. **E. J. Gilbert,** with **W. J. Rattle** as consulting engineer. The ore is as good as Chandler or even better.

Other Mines in Ely Group.

The Zenith mine, situated east of the Pioneer, has been persistently and faithfully developed to a considerable depth without discovering any large amount of ore. The jasper belt is wider on this property, and the ore is not concentrated so far as explored. Capt. **Nick Cowling** had charge of the work here, and managed to produce 29,379 tons of fairly good ore; but the company suspended operations in 1893.

Other tracts of land situated on the strike of these ore deposits to the east have been explored with but little result of an encouraging nature. The jasper lenses are found at intervals for three miles and project in bare outcrops in section 30, 63-11, over portions of which there has been costly litigation for ten years past. But even here the existence of merchantable deposits is not definitely proven.

General Considerations.

With soft ores, bessemer and non-bessemer, and manganese ore as well, on the Mesabi, and hard ores on the Vermilion, Minnesota is able to meet all requirements for iron and steel making ores. In view, moreover, of the cheapness of production of the soft ores, it is inevitable that the Minnesota output must increase with great rapidity in the next few years. Natural causes here form too strong a combination to be overcome by artificial ones. And when to natural advantages are added the wealth and engineering and practical ability at the command of the companies now operating here, it is evident that in a short period of time the North Star state will be second to none in the production of iron ore.

PRODUCTION OF IRON ORE BY MINNESOTA MINES TO DEC. 31, 1894.*

NOTE.—The following table agrees with other published statements of the Minnesota Survey in its reports and in the various Legislative Manuals, but it differs in some particulars from the figures given in the Marine Review, Cleveland, Ohio, Jan. 17, 1895. When such is the case the figures from this latter source are inserted in parentheses.

NAME OF MINE.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	TOTALS.
Vermilion Range.												
Chandler					56,712 (54,612)	306 000 (306,220)	336,002	375,866 (373,969)	651,655	435,930	562,087 (558,050)	2,724,252 (2,716,438)
Minnesota	62,124	225,484	307,948 (304,396)	394,910 (394,252)	455,241 (457,341)	535,538 (535,318)	532,272 (532,000)	517,570	498,353	370,303	391,612 (390,463)	4,291,355 (4,287,604)
Pioneer						3,100 (3,144)	12,016 (12,012)	3,079	2,651			20,846 (20,886)
Zenith									14,991	14,388		29,379
Totals	62,124	225,484	307,948 (304,396)	394,910 (394,252)	511,953	844,638 (844,682)	880,290 (880,014)	896,515 (894,618)	1,167,650	820,621	953,699 (948,513)	7,065,832 (7,054,307)
Mesabi Range.												
Auburn											110,809 (108,210)	110,809 (108,210)
Biwabik										151,500	90,048	241,548
Canton										24,416	213,853	238,269
Cincinnati										26,372		26,272
Commodore										65,137		65,137
Duluth Iron Mining Co.										37,626		37,626
Franklin										46,617	223,399	270,016
Hale										3,616	24,167	27,783
Lowmore										1,645		1,645
Minnewas										13,858	2,140	15,998
Missabe Mountain										123,015	505,955	628,970
Mountain Iron									4,245	119,818	573,440	697,503
Norman											39,008 (38,999)	39,008 (38,999)
Vega											5,628	5,628
Totals									4,245	613,620	1,788,447 (1,785,839)	2,406,312 (2,403,704)
Grand Totals	62,124	225,484	307,948 (304,396)	394,910 (394,252)	511,953	844,638 (814,682)	880,290 (880,014)	896,515 (894,618)	1,171,895	1,434,241	2,742,146 (2,734,452)	9,472,144 (9,458,011)

* From Twenty-third annual report, Minnesota Geological Survey.

PAPERS

READ AT THE

THIRD ANNUAL MEETING.

ADDRESS BY THE PRESIDENT,

J. PARK CHANNING.

GENTLEMEN AND FELLOW MEMBERS:—

I desire to express my sincere appreciation of your confidence in me evinced by your action at the last annual meeting in electing me your president. Permit me to thank you for the honor, and to wish for the Institute and its members as bright and useful a future as its inauguration promised.

With our organization began a new era on Lake Superior, in which, side by side, we are enabled to compare our virtues and correct our errors. No man is so well endowed by nature that he cannot learn from others and be benefited by their experience. As Sir William Temple has said, "The abilities of a man must fall short on one side or the other, like a scanty blanket when you are abed—if you pull it upon your shoulders, your feet are left bare; if you thrust it down to your feet, your shoulders are uncovered."

In selecting a subject for an address to the institute, I have determined for the time to neglect the strictly economical side of mining and to call your attention to the ethical. Mining, like all problems, is in the nature of a polyhedron; we must examine all the faces and angles to fully appreciate the crystal.

Our worthy past president, in his address last year, gave us a most interesting account of the evolution in mining on Lake Superior for the last fifty years and his prediction for the next quarter of a century. In his address we saw the wonderful increase in efficiency of labor due to increased economical devices and the utilization of power.

The question presents itself: Have we in the rush and push of the last fifty years' struggle for material prosperity, devoted a proper amount of attention to the life, health and comfort of the miner? A large proportion of humanity will not take care of itself, will not follow the common laws of health or nature. I regret to say we must use force to compel them.

Only a few days ago the press noted the closing down of a factory in the south where flints were ground, because of the enormous death rate among its employés due to inhaling dust. Masks and respirators were provided and yet the men would persistently neglect to wear them.

You all, no doubt, know the difficulty occasioned in trying to close a contaminated well or pump, of keeping contagious cases isolated in a community, or trying to prevent miners thawing powder over a lighted candle, or drilling or picking out a missed hole.

While the natural carelessness of mankind is difficult to overcome, it does not excuse us who know better from continually exerting our influence for right. In 1887 the State of Michigan passed a law providing for the appointment of mine inspectors by the various counties in the State in which mining operations were carried on. The duties of these mining inspectors were to examine the mines from time to time, and in case they found men working in dangerous places to order them out, and in case the men were ordered back by the manager of the mine and any accident occurred, then it constituted *prima facie* evidence of liability for personal damages against the operators.

The law also provided that shafts should be fenced, and that the ladder roads should be divided and cased, and that cages, skips, cars and buckets used in the transportation of men should be protected with a covering. It also provided that the inspector should report each year to the board of supervisors of his county the accidents that had occurred and under what circumstances, and to indicate which of these were due to the negligence of the men killed or their fellow workmen, and which were due to the negligence of the operators or their managers.

No power was given the inspector either to begin or recommend the beginning of action against any one for carelessness or direct contravention of orders. Starting in on so new a departure for Michigan, the legislature was unquestionably correct in its caution about delegating power to the mine inspectors. Now, after seven years trial of the law, it is appropriate to consider it and its results.

This winter I have collected as far as possible the reports of the various mine inspectors with the following results; In Gogebic county the reports for seven years are available, showing the number of men employed on the surface and underground, the deaths on surface and underground, and detailed accounts of each accident leading to deaths.

On the Menominee range we have the reports of Menominee county from 1888 to 1891 inclusive, and the reports of Dickinson county, the new name for that portion of Menominee county containing the mines, from 1892 to 1894, inclusive. Only the last two years divide surface from underground men.

In Iron county a careful examination of the records at Crystal Falls shows a report setting forth the death of nine men but failing to give the year. Also a report for 1893 showing the death of two men, a special report for 1893 on the Mansfield cave-in, and a report for 1894 in which there were no fatal accidents recorded. None of the reports, except the last, give any statistics and so the whole county has been omitted in compiling tables.

Of the reports of Marquette county, that of 1888 could not be found. The reports of 1889 and 1890 were meagre and gave the total accidents and the total number of men, not noting those on surface and underground. From 1891 to 1894 inclusive, they were quite full but failed to state the number of men underground and those above, only giving the totals.

In the counties producing copper, I have secured only the published reports of Houghton county from 1890 to 1894, inclusive. These give the total accidents with a description of each and the total number of men employed at and around the mines. This latter figure, I am informed, includes underground men and those at and around the shafts and does not include employés at the mills. So far I have not been able to find out how many of the 7,518 yearly employed are actually underground men. I have not made investigations in Keweenaw nor Ontonagon counties, but these counties have not published their reports and at best the number of men employed would be low.

While the law does not compel the making of returns by the mining companies, they have usually coöperated with the inspectors in making the statistics of value.

In classifying accidents, each of the foreign countries has methods of its own. Prussia divides them as follows:

Blasting accidents.
Under cutting.

Sinking of pillars and sides.			
Fall of roof.			
Falls into	Self acting shafts and planes.		
Machinery of			
Various in			
On ladders		Traveling	Shafts.
On man-engines			
Going in	Regular hoisting roads		
Going out			
Going in	Exceptional hoisting roads		
Going out			
Falling into		In shafts	
Falling objects			
Various			
Mechanical tramming	Underground haulage.		
Hand or animal tramming			
Explosions	Explosives or gases		
After damp			
Irrespirable gas.			
Underground machinery.			
Water breaking in.			
On surface.			
Miscellaneous.			

In Great Britain the following divisions are given by direction of the Metalliferous Mines Act:

Falls of Roof	Falls of ground	Underground.
Falls of Sides		
Overwinding	In shafts	
Ropes and chains breaking		
Whilst ascending and descending by machinery		
Falling in shaft from surface		
Things falling from surface		
Falling from part way down		
Things falling from part way down		
Miscellaneous		
Explosions of powder	Miscellaneous.	
Suffocation by gases		
Irruption of water		
Falling into water		
On inclined planes		
By trams or tubs		
By machinery underground		
Sundries underground		

By machinery on surface Boiler bursting On railways and tramways Miscellaneous on surface	Surface.

In the table which I have prepared I have adhered quite closely to the British division adding a number of classes and attempting to make the table as full as possible.

For the seven years ending September 31, 1894, there have been employed in the iron mines of Michigan (not including Iron county) an average of 13,770 men per annum; of these it is estimated, partly by actual figures and partly by the assumption of ratios, that 10,305 found employment underground and 3,465 on surface. During this period 400 men were killed, not including Marquette county for 1888 for which there are no returns. Of these 400 men killed, 378 were killed underground and twenty-two on surface. The total death rate per thousand per annum is 4 490 including all men employed; taking the surface men out, we have a death rate of 5.670 per thousand men employed underground per annum in the iron mines.

Turning to the copper mines of Houghton county, we find the average number of men employed 7,518 and the total deaths in the last five years amounted to 132, of which 126 were underground and six on surface. As was before noted, the proportion of underground men being unknown, we can only say that the ratio per thousand men of total employès per annum is 3.511.

These ratios are very high. In the Zeitschrift fur das Berg und Huttenwesens im Preussischenstaate for 1893, one can see the records in the metalliferous mines of Prussia for many years. From 1867 to 1890 the ratio is only 1.356 per thousand per annum. For the decennial period of 1881 to 1890 it is 1.253, for 1891, 1.035 and for 1892 it is 1.081.

Turning to Great Britain, and more particularly to the hematite district in North Lancashire, Mr. Hedley, H. M. Inspector of Mines, in his report for 1891 gives 6,891 employed underground, 2,112 on surface and a total of twelve killed underground and none on surface. In 1891 in his district there were 7,260 underground and 2,379 on surface, total deaths twelve. The average of these two years gives about 1.7 per thousand per annum.

In the Cornwall and Devon districts, the figures from 1873 to 1891 show 529 deaths out of a total of 327,045 men for nineteen years or 1.57 per thousand per annum. These figures include the surface hands, but as about two-fifths are surface men, this rate would be increased.

T. Le Neve Foster has made the investigation and gives from 1873 to 1882 in Cornwall-Devon 280 deaths out of an average of 10,619 men underground, or 2.63 per thousand per annum.

In the districts in which Mr. Foster is inspector of mines, North Wales and the Isle of Man, his reports of the copper, zinc, lead and other mines, inclusive of the slate mines, give the deaths per thousand and per annum of underground men from 1875 to 1884 as 1.79, and the successive years 1885 to 1891 as 3.44, .37, 1.14, 1.02, .64, 2.36, .70.

Taking the whole of the mines under the Metaziferous Mines Act in Great Britain, we have the following:

Period.	Below Ground.	Above Ground.
1873 to 1882	2.348	0.578
1883 to 1892	2.145	0.392

Compare these figures with Michigan as follows:

County.	Below Ground.	Above Ground.
Gogebic	7.332	.647
Menominee	5.689	1.135
Marquette	4.768	1.093
Iron district	5.670	.981
Copper district	3.511	[including above ground.]

It will be seen that the results are not to be commended.

It would be easy to give more figures for purposes of comparison but they are needless. To those who wish to further investigate the statistics, material will be found in Chapter XVII of C. Le Neve Foster's "Text-Book of Ore and Stone Mining," and also in the "Revue Universelle des Mines" for 1890 in a report by M. Paul Habets on "Les Accidents dans les Mines et l'Exposition Generale Allemande pour la Protection contre les Accidents."

Turning our attention to an analysis of the Michigan accidents, we observe a rate of 4.768 for Marquette, 5.689 for Menominee an l

7.332 for Gogebic. It is noticeable that these figures are inversely as the ages of the respective ranges and point to the probability that the oldest range has the best workmen. There seems to have been an improvement in Gogebic county where the rate in 1888 of 9.212 has fallen to 3.015 in 1894. In 1893 it was the frightful ratio of nearly 11 per thousand. This was due to a great extent to the loss of ten men in the Norrie cave. Without these ten. the rate would have been 7.3, still high, but the average of the seven years.

In Menominee and Dickinson counties there has been no marked improvement except that the last year was a little below the average.

In Marquette county the rate has been very regular, not ranging two-tenths either way from the average for the six years.

Out of the 400 deaths reported in the iron mines, 162 were due to falls of ground, or 40 per cent. of total. In the metalliferous mines of Great Britain it is 34.4 per cent., in Cornwall-Devon it is 25.5 per cent. In our own Houghton county, the total is 38 out of 132, or 29 per cent. It is in the prevention of this class of accidents that there is much room for improvement. Men become careless and fail to stand props or put in the regular timber when it should be done. If mining on square sets, they will blast out a large opening too big for one set and yet not large enough for three. Sooner than put in the center set and then cut out for the two side sets, an attempt will be made to cut out for all three; the space becomes too large and then a fall occurs. In drifting in hematite, back laths will not be driven when they should be, or if the drift does not need timber, the crown will be made flat instead of arched.

A common method is for trammmers to go into a working place to load ore too soon after a blast has been set off and before the ground has been examined by a competent person and the loose pieces barred down.

In hard ore stopes and in copper rock stopes, the last class of accidents is peculiarly liable to happen. These falls of ground are less liable to be noticed, as they come like casualties to a skirmish line, one at a time.

Ten men lost their lives in a single accident at the Norrie mine at 5 A. M., Sept. 29, 1893, caused by the caving in of a room on the sixth level. This room was three sets wide and seven sets long, and the sets were seven and one-half feet center to center. There had been no cracking of the timbers in the room to give warning, there was only a sudden cave. The immediate cause of the cave does not seem to have been determined.

The next great division of accidents covers those occurring in shafts. The first sub-division is overwinding. There was but one of these accidents and that happened at the Calumet and Hecla mine on May 14th, 1893. On that day the sinking engine at the Red Jacket vertical shaft was overwound and carried the south bucket with ten men in it up to the top of the head frame where the rope connection to the bucket gave out and the men were precipitated 3,000 feet. The engine was a double tandem compound, driving two seven-foot grooved wheels around which the rope made three turns and then ran out over a tail wheel and back to the shaft. There was a bucket on each end of the rope so that the winding was in balance. The indicator consisted of a steel band mounted like an ordinary band saw, the lower wheel that drove the band being connected to the engine. There were two discs, two inches in diameter, attached to this band, one to govern the landing of the north bucket and one the landing of the south bucket. The slots for these discs to appear in were so arranged that, although without design, a small portion of the north disc appeared as a kind of preliminary signal for the approach of the disc governing the south bucket, and *vice versa.*

It appears, from the report of Captain Hall, the mine inspector, that the engineer hoisted the men at the rate of seventy revolutions per minute instead of forty-five, the regulation speed for hoisting men, i. e. at 1.540 feet per minute instead of 990, and that just about that time, the disc governing the north bucket fell off the band. The engineer evidently watched for the corner of this disc to show and when the regular south full disc appeared, must have mistaken it for the corner of the north disc and imagined the bucket was some 900 feet down the shaft and continued on, without slacking speed, into the head frame. The engine was not provided with any automatic stop, nor were there disengaging hooks on the bucket. It is doubtful if any hooks or catches would have caught the bucket coming up at the speed it did.

No accidents have happened from ropes breaking. "Whilst ascending or descending by machinery" is responsible for the death of twenty-five men in the iron country and sixteen in the copper country. Most of these accidents are due to riding on unauthorized means of travel, such as loaded skips and cages, or by sticking the head or body out from the cage while in motion. If men were liable to fines for riding on unauthorized roads, I think this ratio of .375 per thousand could be reduced to .06, which is about the figure in Great Britain and Prussia.

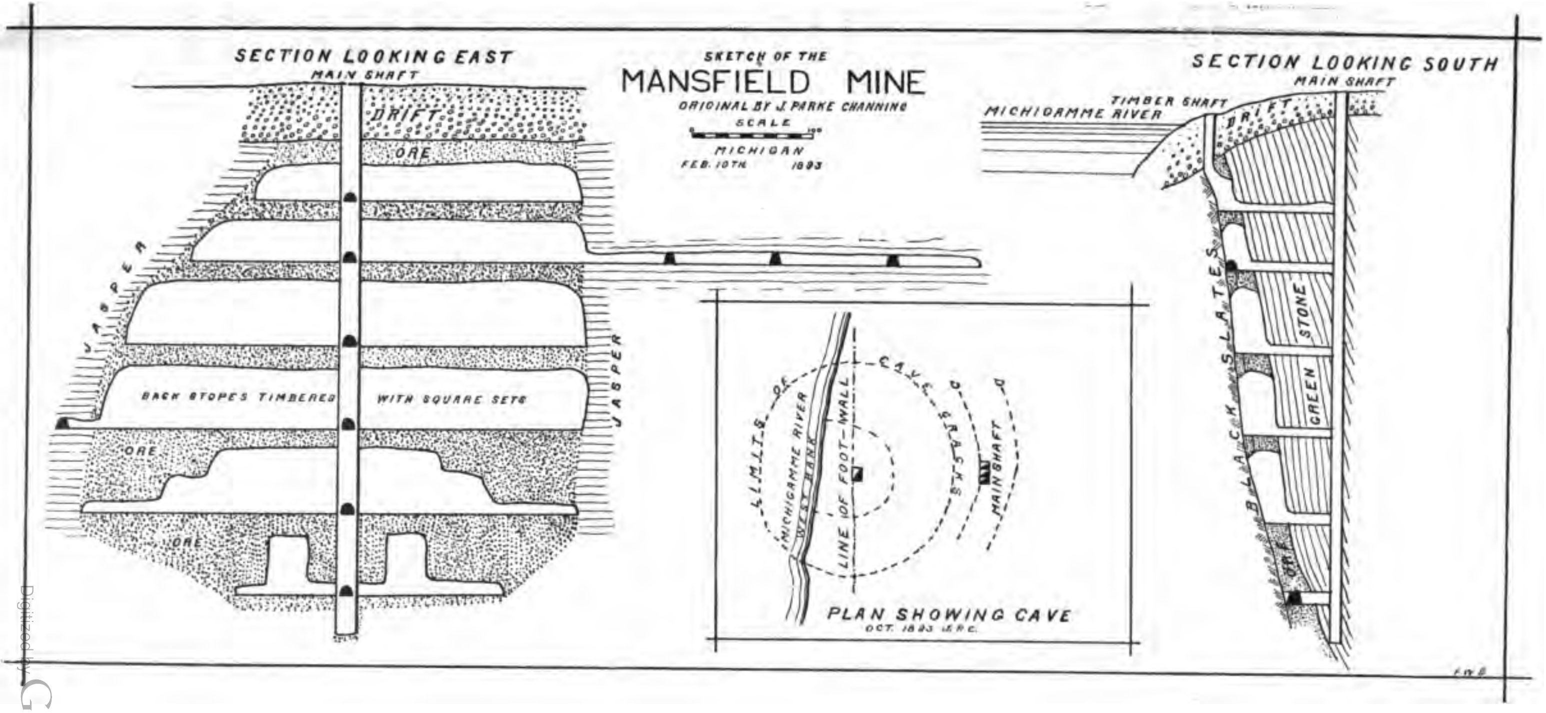
In hoisting men out from a mine, it is preferable not to use a drum connected to the engine by a friction clutch. These frictions are liable to slip, particularly if changes of temperature occur in the bands.

At the Calumet and Hecla the drums of the regular engines for hoisting men are positively connected to the drum shaft and these geared to the engine shafts. The engines are so proportioned that they cannot break the winding rope in case the man car catches in the shaft. No accidents have happened using these engines.

"Falling into shafts from surface or things falling into shafts from surface," are not high rates. The law compelling the fencing of shafts has much to do with this and shows the advantage of strict rules.

"Falling from part way down" claims fifty-three in the iron country and eight in the copper country. We should expect this difference on account of the greater steepness of the iron mine shafts. There is no regulation in the mining laws compelling the fencing in of underground plats, and it is surprising the number of men that will deliberately walk into an open skip or cage hole. Many ladder roads in underlay shafts are straight away, and if a man ever slips he is liable to go to the bottom, or at least to the next level. Some shafts have vertical ladders. The rule should be that no ladder should be over twenty feet long nor placed at a steeper angle than eighty degrees.

"Hit by things falling from part way down" claims thirteen men in the iron country and four in the copper country. Careless lashing



SKETCH OF THE
MANSFIELD MINE
ORIGINAL BY J. PARKE CHANNING
SCALE
MICHIGAN
FEB. 10TH 1893

of timbers while being lowered is a fruitful cause of these accidents, also carelessness in dumping ore or throwing tools into skips.

"Hit by passing cage, skip or bucket" could in part be prevented by the fencing of plats and careful casing of shafts, and indirectly by the use of first motion winding engines, as clutches will slip while the engine is standing or just starting. The copper country has eleven deaths against only twelve in the iron country.

The deaths due to explosions of powder are very excessive, being fully five times as great as in Prussia or Great Britain. They averaged at least five a year in the iron country and six a year in the copper country. This makes a ratio of .51 in the iron country and nearly one per thousand in the copper country.

The utmost recklessness is shown in handling powder, thawing it over open fires or candles, tamping with drills, drilling and picking out missed holes and going back too soon after a supposed missed but in reality hang-fire hole. In Great Britain a miner who picks out a missed hole is liable to imprisonment, and the manager who does not provide proper receptacles for carrying powder is also liable.

Mine fires have caused some seven deaths in the iron country and, including a fire in 1888 (not included in the table), eleven deaths in the copper country. This subject has received much attention in the last few years, and the danger from underground timber becoming ignited fully recognized and guarded against. Oily pump houses and improperly lagged steam pipes must be avoided.

"Irruption of water" has no accidents to its debit in the table, owing to the omission of Iron county, although in 1893 on the night of September 28th the Mansfield mine in that county caved in at the surface letting in the waters of the Michigamme river and drowning twenty-seven men. This was, curiously enough, only twenty-four hours before the cave-in at the Norrie mentioned previously.

The Mansfield mine was working a lens of ore which outcropped along the west bank of the Michigamme river. The trend of the formation was such that the south end of the lens was under the river. The dip was pretty steep to the west away from the river.

As is shown in the sketch, the mine was operated by a main shaft in the hanging and a small timber shaft (the discovery shaft), close to the river bank. The main shaft was down thirty feet below the sixth level or 430 foot level. The ore body was twenty to thirty feet wide and 240 feet long near the surface, lengthening out to 410 feet as it went down. The ore was stoped out on square sets the whole length of the body, leaving some backs between the levels but no pillars to support the hanging wall, not even behind the shaft except at the sixth level. Some filling had been run in at the north end of the mine. The sketch which is shown was made a few days after a visit on February 10th, 1893, and is only approximate, being intended at the time to show the geological conditions.

The pumping was done from the sixth level by a compound condensing steam pump. At the time of the break-up in the spring, the melting snow on the ground west of the mine caused a very heavy rush of water through the seamed greenstone that formed the hanging of the mine. No large amount of water, it seems, came from the river. The pump was run at an excessive speed, breaking the flange that connected the column to the discharge pipe of the pump. Before a new flange could be put in, the pump was drowned and the two bottom levels of the mine were flooded. These bottom levels were recovered by sinking pumps, but it took some two months to accomplish the result. As will be seen in the sketch, the major portions of the ore reserve were on these two levels, and yet during the period, ore was being mined from the upper levels. In regard to the exact points from which this ore came or its amount, I am not informed.

On the night of the accident there were the usual number of men in the mine. About midnight and without any immediate warning the ground around the timber shaft caved in and for two hours the bed of the Michigamme river below the mine was dry, as the stream flowed into the workings. A number of the men escaped, including the pumpman who was at the big pump station, but twenty-seven of them were drowned.

The report of the mine inspector places the accident as due to the knocking out of some supports in the timber shaft. That the mine inspector had extra fears for the safety of the mine, is shown by his statement that between June 23rd and September 28th he had visited the mine at least three times each month, whereas the law requires only one visit every sixty days, and further, by the appointment of an under captain at the mine as deputy inspector. This under captain had been in the mine three hours before the accident but was on surface at the time of the cave.

I visited the location October 10th, some two weeks after the accident, and found surface cracks west of the shaft and have been informed that for some days previous to the cave the railroad tracks west of the main shaft had to be surfaced because of their becoming disturbed.

It is to be regretted that accurate verified maps of the mine are not to be obtained so that the exact amount of the back of ore under the river bottom could be ascertained.

Returning to the table, "falling into sump" claims but one victim while "falling through winzes" and "timbers" each have twenty deaths charged to them. Falling through winzes could be prevented in part by requiring that they should be either covered or fenced. If used to lower timber through, at least three sides could be protected. Falling through timbers is quite high on the Gogebic range for the reason that very large and high rooms are stoped out on square sets and no filling run in. Care should be taken in the lagging used to work on. It should be round or sawed and not split, and should be long enough to reach clear across the caps.

Underground tramming accidents are very low, principally because power has been but little used and for the most part slow-moving endless cables. Two electrical plants are now in operation, however.

"Underground machinery," "force of wind from cave," "simple falling down," "fall of timber and rock rolling down stope" each claim a few victims which amount in all to twenty-five deaths.

Regarding accidents on surface, of which there are twenty-two in the iron country and six in the copper country, the rate is nearly one per annum per 1,000 men employed on surface. An occupation that has a death rate of one per 1,000 is considered dangerous, and one per thousand is too high for surface men. Engines of all kinds should be fenced in securely, loading tracks at the shafts should not have too steep a grade and trestles, shafthouses and flights of stairs should be provided with suitable railings.

The returns of the Gogebic range give the nationality and particular class of labor in which the deceased men were employed, as follows:

Swedes	35
Finns	26
English	22
Italians	13
Irish	11
Austrians	8
Bohemians	6
Americans	4
Germans	3
Scotch	2
Poles	2
Canadians	1
Norwegians	1
	134

Miners	76
Timbermen	20
Trammers	17
Laborers	8
Skip tenders	5
Pumpmen	2
Enginemen	2
Foremen	2
Lander	1
Carpenter	1
	134

There are no statistics available showing the birth place of the various employés, so that we cannot say if the ratio is excessive among any particular nationality. If we consider the class of work, notwithstanding that more than half the deaths were of miners, we should find the ratio among miners lower than among the trammers and timbermen. It is these latter classes that are recruited from the ranks of those unaccustomed to mining.

While the death rate in 1894 is lower than the previous years, it must be remembered that this year was one of depression and that the number of men employed was very small. Comparing 1893 with 1889, but little improvement can be seen.

Taking all the figures into consideration, the conclusion seems irresistible that the present mining law has not been a great success.

The mere fact that every fatal accident is sure to be investigated and the occurrence published, has had a moral effect upon mine officials, and although the status of the inspector is indeterminate and his actual authority nothing, his presence and suggestions have for these reasons considerable weight. His influence upon the men themselves has not been much. Knowing his lack of authority, he is smiled upon in a superior way if he tells a man it is not safe to bore a hole in a stick of powder with the point of a candlestick holding a candle, and is assured by the man doing the boring, that he has done so a thousand times and no harm ever occurred.

The trouble with the law is that it is of a most superficial character and hardly can be dignified by the name of a mine regulation act. Take for example the two shaft provisions. There is nothing in the act on this point and yet it is of the utmost importance that every mine has two means of exit.

The method of appointing the inspector by the county board of supervisors, is open to criticism. This board is usually composed of mine managers or officials, and except by popular election, I can conceive no worse way of selecting a man. The salaries paid are small and as a consequence the best men do not seek the places.

In Great Britain the inspectors are appointed by the Crown and are usually taken from the ranks of successful mine managers. The appointment is for life and the inspector is responsible only to the Home Secretary. He may not be interested in any mining company or mining operation in his own district. His orders must be obeyed by the mine managers; if disobeyed, the manager or mine official can be summoned before a justice of the peace and there fined. Either the mine inspector or the mine manager may institute proceedings against any employé who violates provisions of the act.

The mine inspector is authorized to draft special rules for any mine in his district, but the two shaft provision cannot be abrogated save by order from the Home Secretary.

In Pennsylvania the inspectors have been selected by competitive examination to serve for a fixed term of years. I believe, however, the positions are such that men leave them to become managers.

The time has certainly come in Michigan when it is desirable that we take this question in hand and put our state to the fore. Our mining practice is the best, our machinery and our mills the largest and our shafts the deepest in the world. We should not be without a mining law commensurate in its completeness with our material success.

Our legislative bodies, be they never so learned, are not nor cannot be specialists in mining, and it therefore seems that while they should take action in this matter, the law itself should be the deliberate work of a special commission of men whose training has fitted them for the duty.

I would suggest the following composition for a commission of seven men: Three members of the legislature who would represent the interests of the miners, one mine manager who would represent the companies, one regularly graduated mining engineer well versed in practical work who could decide the engineering questions, one of the professors of mining in one of the state institutions who would presumably be conversant with the literature of the subject, and one judge who would see that the law was properly drafted.

If it were deemed advisable to follow the British practice, then the commission would consist of two mine managers, two mining engineers, two miners below the rank of foreman not financially interested in any mining operation, and in default of the usual secretary, a judge or a jurist.

This commission could draft a statutory law, determine the proper number of inspectors necessary to attend to the work, fix the method of their selection and their salaries. The commission should have power to summon witnesses from among miners and mine officials and be enabled to pay them for their time and travel. The question of compensating the commission is a delicate one. There certainly should be enough competent men in the state who would take the positions for the honor and on payment of their actual expenses.

In closing, I beg that the members of the Institute, and that mine managers and their employés will carefully consider the figures and suggestions I have made and coöperate in checking this unnecessary loss of life.

Marquette County.

D.	1891.	1892.	1893.	189
	10	10	9	
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	....	1	2	.....
	....	2	....	.....
	....	1	....	.....
	5	4	5	
	....	....	....	
	....	2	....	.....
---	....	....	....	.....
	3	3	....	
	2	....	....	.....
---	....	....	....	.....
---	....	....	....	.....
	....	2	1	
	1	1	....	.....
---	....	....	....	.....
	1	....	....	.....
---	....	....	....	.....
	1	1	....	.....
	1	....	1	.....
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---	....	....	....	.....
	24	27	18	1
250	* 6,000 4.000	* 5,423 4.978	* 3,872 4.646	* 2,6 4.9
	1	....	....	.....
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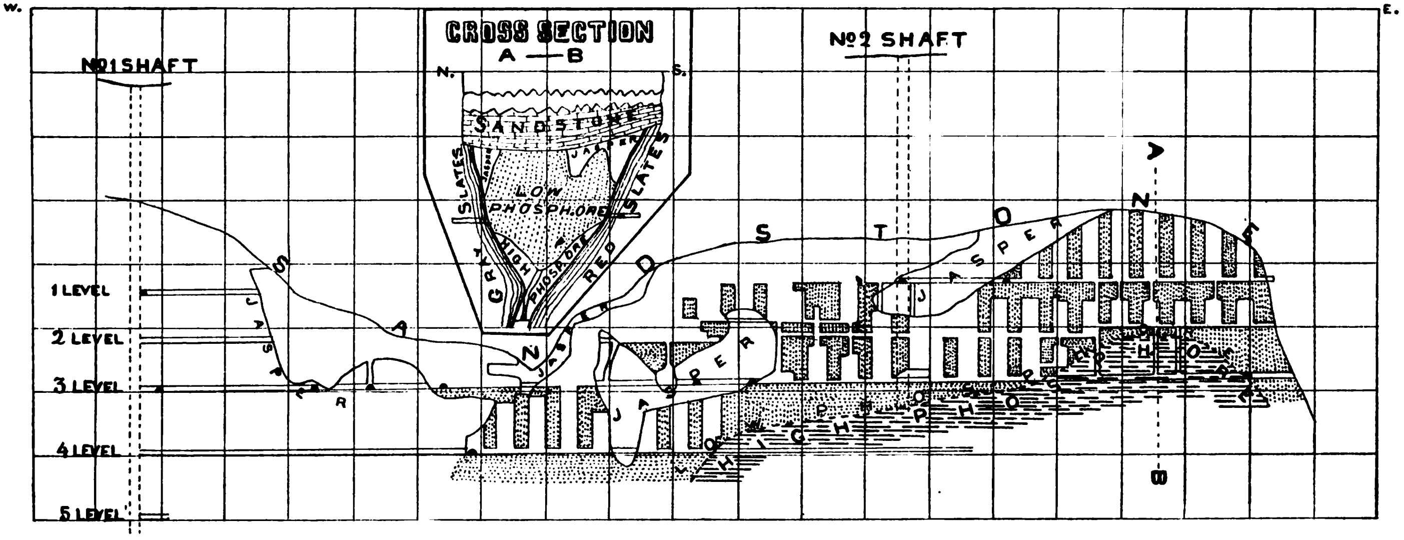
	1	1	....	•
	2	....	....	
	4	1	....	
750	* 2,000 2.000	* 1,807 .553	* 1,290	* 8 2.2
45	28	28	18	1
000 091	* 8,000 3.500	7,230 3.872	5,162 3.487	3,5 4.2

J. P. C.

LONGITUDINAL SECTION OF PEWABIC MINE

SCALE ONE SQUARE = 100 FEET



DISTRIBUTION OF PHOSPHORUS AND SYSTEM OF SAMPLING AT THE PEWABIC MINE,

Iron Mountain, Michigan.

BY E. F. BROWN.

The first shipment of ore from the Pewabic mine was made in the year 1890. During the first three years of active mining, all the ore developed was uniformly a high grade bessemer. Exploratory and opening work conducted during the past two years, however, has shown that the mine contains considerable non-bessemer ore. This non-bessemer ore varies greatly in the percentage of phosphorus contained. The results of samples taken at several hundred different points, show the maximum phosphorus to be 1.100 per cent and the minimum .080 per cent. The average of all non-bessemer ore from present developments would be about .125 per cent in phosphorus.

The high grade bessemer ore is uniform in quality; the shipments of the past five years show an average of .008 per cent in phosphorus.

The foregoing serves to illustrate the difference in quality of these ores. An understanding of the occurrence of these two grades of ore and their relative positions in the mine, can best be arrived at by an explanation of the two sections of the mine shown herewith. From the longitudinal section it will be observed that the ore formation has a heavy capping of sandstone, varying from 200 to 600 feet in thickness. On the west end of the mine, near shaft No. 1, the vein matter is jasper interspersed with thin seams of low phosphorus ore. As we go east on the third level, 500 feet from the surface, lenses of low phosphorus ore are found nearly surrounded by jasper. These lenses of ore increase in size as they extend upward toward the first and second levels. Near the sandstone these lenses unite, forming a wide body of ore very low in phosphorus, but in many places having but little vertical depth from sandstone to jasper.

At a point 1,200 feet east of No. 1 shaft or immediately opposite No. 2 shaft, the ore at the third level becomes practically clean and free from jasper, but near the walls we encounter non-bessemer ore, while a short distance from either wall the ore is still of the low phosphorus variety.

We go 225 feet further and find this level intersecting the junction between the high and low phosphorus ores. Commencing near the second level at a point 1,550 feet distant from No. 1 shaft, the junction of the two grades has a westerly pitch; 100 feet east of this point the pitch is reversed.

It is perhaps worthy of special note, that this junction line conforms very closely to the position of the sandstone capping. Also, that originally the sandstone was the carrying medium of large quantities of the mine water until mining work drained the supply to lower levels. As will be seen from an examination of the cross-section, the junction line shown on the longitudinal section, is the bottom of an inclined trough, somewhat irregular in contour. The sides of this trough have a height varying from 50 to 150 feet. In this section the deposit of high phosphorus ore is shown to be fairly regular. This, however, is not always the case. We find instances where large and small bunches of the non-bessemer ore are completely surrounded by low phosphorus ore. These bunches are always near the main body of high phosphorus ore, usually not more than two or three feet of the better ore intervening.

On the longitudinal section, the junction of the two grades is shown by a well defined line. In mining, this line is not perceptible and can only be determined by analysis. As we approach the line from either direction, the strata, color and general appearance of the ore are unchanged, the percentage of iron being practically the same in either grade. Analysis, however, shows the difference in the phosphorus to be great, and the change of grade very abrupt. As an example;—In driving the original or main drift east on the third level, it was the custom to sample the breast of the drift after each cut was blasted; at a certain point the breast gave an average of .008 per cent in phosphorus. After blasting the breast for a five-foot cut, the broken ore was found to contain .350 per cent phophorus and the newly exposed breast .750 per cent.

The rule here seems to be, that the ore highest in phosphorus is found at the junction of the two grades. As we work into the non-bessemer ore, the ore contains less phosphorus, although it is not uniform. The illustration just given may be taken as a fair sample of the difference in percentage obtained near the junction in opening and mining the low phosphorus ore. It will be seen from this, that in mining the low phosphorus ore, it became necessary to exercise great care.

After some experimenting, the following system of sampling was adopted:

For underground sampling, one man was placed on each shift. It is the duty of each of these men to sample all the ore broken by the blasts on their respective shifts, also to sample all the new faces developed by the same blasts. The man on the night turn must pulverize the samples taken by him and have them in the laboratory at 7:00 o'clock A. M. and at 8 o'clock A. M. we have the approximate amount of phosphorus contained in the ore at all the new points in the mine. We are thus able to judge the grade of all the broken ore in the mine at any one time, as well as the quality of the new faces exposed.

The same rule works on the day turn, except that at 7:00 o'clock P. M. we have received from the laboratory the results of the day sampling. To accurately locate the source of all samples, a base line is established throughout the length of a given level; on the laboratory return, we record the distance north or south of the base line in a given room.

For the information of the captains and bosses engaged in handling the ore, a tracing of each room is prepared; on this tracing is marked, at the end of each shift, all the places where broken ore has been left, also the quality of such broken ore as shown by the samples previously taken.

As a check on the underground sampling, two sets of samples are taken on surface. First,—As each tram car is hoisted to surface, the lander will take from it a large shovel full of ore; at the end of each ten-hour turn, a large sample is formed by combining all shovel samples taken during the day. This large sample is quartered down to suitable size for laboratory work. The determination of the phosphorus in this sample is made as soon as possible. This set of samples is designated as 'day' or 'night' hoist.

The second set of samples is taken from the railway cars, a box containing about forty pounds being taken from each car. The boxes are numbered to correspond with the car and stored in a shed. When the cars are dumped into a cargo, we receive from the shipping ports a list containing the car numbers of all the cars entering into the cargo. With this list we select the boxes of ore corresponding to the car numbers. The ore in the boxes is all crushed, dumped in one pile and from this combined sample, the laboratory sample is taken in the usual manner.

The following is the method of sampling railway cars:

The sampler has four cords attached to two poles; each cord is one foot distant on these poles from its neighbor. The cords have knots in them one foot apart. These cords are drawn over the top of the loaded car and the sampler takes a small garden scoop of ore from points under the knots irrespective of the quality of the ore. This sample is designated as "cargo sample."

I believe that with this system of sampling cargoes more uniform results are obtained than is possible by any other method. The two sets of surface samples have a further use as a guard against the mixture of grades caused by careless mining. If the day or night hoist samples show an amount of phosphorus above the ordinary, we know that some ore of poor grade has been hoisted. In this case, all the railway cars composing the particular hoist are held in transit or at the shipping port until the box samples representing the cars are analyzed separately. In this way we readily pick out the cars that contain the poor grade mixture and have them dumped as a separate grade.

During the year 1894, all of the low phosphorous ore taken from the mine came from points near the high phosphorous ore. As evidence of the efficiency of our system of sampling, 301,000 tons of ore were shipped, averaging about .007 per cent in phosphorous; in addition to this several thousand tons of non-bessemer ore were mined and shipped.

DISCUSSION.

Mr. Per Larsson: The facts as to the distribution of phosphorus in the Pewabic mine which have been stated in Mr. Brown's paper are quite similar to those obtaining in the Aragon mine.

In that mine the ore formation is very much folded and distorted. It is found that the ore highest in phosphorus occurs underneath the high grade basins.

The planes of division are irregular and yet well defined, but they can seldom be perceived by the eye; they can only be determined chemically.

It would seem evident that phosphorus has been dissolved out of the ground where the choice ore now occurs, and that it has been deposited in the ore underlying it, and also that the change took place after the breaking up of the formation. In fact there seems to be a close relation between the breaks in the ore formation and the quality of the ore, inasmuch as we find the ore lowest in phosphorus in those places where the formation is most distorted.

It is also found that the area of ore extremely high in phosphorus (underneath the choice ore) is small, and that the ore in the bottom of the mine is of a medium grade, above the bessemer limit to be sure, and yet suitable for bessemer mixtures. This grade is equal in quality to the average red hematite ore of the Menominee range, and it would seem that it has not been subjected to the changes that have largely eliminated the phosphorus in the better grades.

Mr. J. Parke Channing: Are there any other members who have information to give?—If not I would like to say that I have been told that at the Lake Angeline mine there were rooms filled with red rock and then, in order to pack this rock, a stream of water was turned on, and when the pillars between the rooms were mined they were found to be of non-bessemer ore, whereas the ore from the rooms was bessemer. In assaying this red rock it was found to contain a large percentage of phosphorus.

Mr. W. J. Olcott: If the percolation of water carries the phosphorus from the upper portion of the deposit to the lower, I would like to ask for an explanation of the condition on the Mesabi, where we find that the high phosphorus ore occurs as a rule on the top, and under it a layer of low phosphorus ore.

Mr. W. Fitch: Would not an explanation of that be possible in this way; that on the Mesabi range they have not had so much action of percolating waters on the upper layers, whereas, in the case of these others, particularly in the case of the Pewabic, we have underlying that sandstone and on top of the ore, a chance for heavy water courses which would be sufficient to work the elimination and bearing down of the phosphorus through the porous strata.

Mr. E. F. Brown: We found in the western end of the mine thin seams of low phosphorous ore scattered through the jasper that carried large quantities of water, and as we approach the sandstone at every point we encounter considerable water, but, of course, as lower levels touch the sandstone it is turned away to the junction of the drifts lower down. The formation of jasper itself is very low in phosphorus. Besides the seams of low phosphorus ore which conduct the water, there are a considerable number of large water courses through the jasper. Near these we find a belt of low phosphorus, lean ore, but as we get farther east, near the high phosphorus ore the jasper that we encounter is usually considerably higher in phosphorus than that farther west, where the water has had a freer course.

Mr. H. V. Winchell: It seems as though it is possible to explain the Mesabi condition by supposing that the Mesabi ore deposits were formed before the last glacial period, and that the process of downward percolation had carried the phosphorus all to the bottom of these ore deposits, and that the upper portion of the deposit was afterwards eroded. The ore was then covered by glacial drift.

Mr. F. P. Mills called attention to the fact that at the Cleveland Lake shaft the bottom of the deposit is lower in phosphorus than in any other portion of the mine.

Mr. W. J. Olcott: I presume we have a great deal more trouble in sorting the ore at the Mountain Iron mine than Mr. Brown has experienced at the Pewabic. This last summer we made an effort to determine whether there was any regular law in regard to the position of the high phosphorus ores in a deposit, and accordingly we made a plat of the different stopes removed by the steam shovels, and found that in making a cut fifty feet might be "Mountain Iron" grade and the next fifty feet "Helmer," and possibly the ore in the same locality on the next cut might be "Tubal." I don't believe that a study will solve this problem, and the only way to sort the ore is by frequent and careful analyses.

MR. PER LARSSON: I don't think that we could make a general rule for all mines, but I think that we can study the condition of each case and make a rule for each case. I would not encourage the belief that there is no way of explaining particular cases. There certainly is a reason in this case for instance. Why, under a heavy sandstone capping they have this extremely low phosphorus ore and that at a certain line they encounter a high phosphorus ore. There are, in individual cases, rules, but they don't apply to every case probably.

Mr. G. H. ABEEL: I might say that at the Montreal mine we found our low phosphorus ore in the center of the vein, and that on the foot and hanging walls the ore went way up in phosphorus. At the hanging it may sometimes run above the bessemer limit.

EFFICIENCIES OF SOME PUMPING PLANTS ON THE MENOMINEE RANGE.

BY PER LARSSON.

We probably all recognize the fact that in the selection and care of mining machinery, particular attention should be paid to the efficiency of the pumping plant on account of the continual and heavy duty that it is, in most mines, called upon to perform. With a view to ascertaining what efficiencies we are getting from our pumps, under ordinary circumstances, I have collected the records of some fuel tests that have been made at mines on the Menominee range, and I herewith submit the results in a tabulated statement. I trust that the presentation of these records will lead to the publication of similar data from the other ranges and to criticism by members more capable than I am of analyzing the results.

Referring to the table on next page the following information may be given:

The test of the Vulcan Cornish pump was made Jan. 20th this year, the duration of the test being 24 hours. Two 72"x 18' horizontal return tubular boilers were fired with Mansfield lump coal raising steam to ninety pounds pressure. The steam pipe leading from the boilers to the basement of the engine house is four inches in diameter and 250 feet long. This pipe is apparently too small as shown by the sharp vacillation of the steam gauge during each revolution of the engines. It was also leaking quite freely at one of the joints during the test. On the foundation floor the four inch pipe is connected to a ten-inch steam pipe leading to the engines. These are 28"x 36" duplex, slide valve engines with two condensers on line with the engines. The injection pipes are three inches and air pumps eighteen inches in diameter.

EFFICIENCIES OF SOME PUMPING PLANTS ON THE MENOMINEE RANGE.

	Diam. of Steam Cylinders.		Diam. of Plungers.	Length of Strokes.	Length of Strokes actually made during test.	Displacements per min. in gallons.	Slip in per cent of displacements.	Number of double strokes per min.	Height of lift, feet.	Coal consumption per hour, pounds.	Percentage of ash and clinkers.	Foot pounds produced per 100 lbs of coal.	Cost of Plant.	Type.
	High Pressure.	Low Pressure.												
Vulcan Cornish Pump...	28	......	16	120	120	727.5	9	3.18	1,015	1,089.4	7.9	30,866,000	$62,421 85	Duplex condensing.
Vulcan Worthington Pump	25	43.3	12	36	32⅝	697.7	5	10.90	1,020	1,053.1	7.95	32,126,000	20,012 47	Duplex compound condensing.
Aragon Worthington Pump	15	25	10	24	22⅓	510.6	5	17.61	522.7	600.	9.6	21,147,000	....	Ditto.
Pewabic Hughes Worthington Pump............	24	40	12	18	15⅞	870.4	5	28.	691	1,093.5	6.6	26,148,000	....	Ditto.
Chapin New Cornish Pump	50	100	28	120	120	1,342.3	3	4.39	607.67	585	......	68,996,000	....	Single compound condensing.
						Capacity of buckets, gallons.		Trips per minute.						
Hamilton Baling Plant..	....	......	....	......	....	2,615	....	1.46	1,146	1,406	7.7	63,715,000	....	Duplex Corliss hoisting engines.

The power of the engines is transmitted through a spur gear, the ratio of which is one to eight, to timber connecting-rods 10′-1″ between centers, and further, through thirteen and one-fourth inch pumprods working 7′-1″ apart, to two sets of sixteen-inch plungers on the sixth and twelfth levels respectively. Balance boxes are placed on the surface and on the tenth level. The type of water valves used is the single, steel packed clack. The plungers are three feet five inches apart, the offsets from the rods being made on the inside. The two pumps have a common discharge, the arrangement being designed by Mr. J. B. Lyons.

The cost of this Cornish plant was as follows:

The contract price for the engine, gear and castings, for bobs and two 16″ pumps in 1885 was $22,000, delivered. It is probable that this plant could have been laid down at the mine in 1892 for $20,000. Two additional 16″ pumps in 1893, $2,650. The foundation for this plant laid in 1892, including that for the building and bob pits cost $13,644.20, but the location was on a side hill. The former location in 1886 was more favorable. The expenditures then were:

For engine bed	$4,758 00	
For bob pit	4,996 56	
		$9,754 56
Erecting engine, including piping (estimated)		4,000 00
Pump bobs, exclusive of castings in 1886		587 75
Building, frame, including stone foundation, in 1886		4,299 37
Estimated cost of 1,000 ft. double pump rods		512 00
Estimated cost of plates and bolts for same		2,906 00
Cost of cutting pump stations and setting up pump rods		2,412 17
Estimated cost of pump compartment, 4x10		10,000 00
18″ pump column		5,300 00
Total		$62,421 85

The time of erecting was ten months, from breaking of ground to starting of pump

The plant was originally erected in 1886, but on account of a mine fire which destroyed the pump shaft, it was moved in 1892 to its present location.

The test of the Vulcan underground pump, which is a "Lehigh" pattern Worthington, was made February 24, the same boilers being fired as in the case of the Cornish pump. The length of the steam pipe is 1,330 feet, of which 680 feet are six-inch and the balance five-inch. During the test considerable condensed water entered the cylinders, as no separator had then been placed in the steam pipe at the pump. A steam pressure of seventy pounds was carried in the pump house. A Worthington independent condenser is connected to the low pressure cylinders. All steam cylinders are steam jacketed. The water is raised directly to the surface through an eight-inch pipe. The cost of the plant is as follows:

Cost of pump and condenser delivered		$12,182 61
8-inch water pipe and fittings		1,402 46
5-inch steam pipe and fittings		750 00
Erecting pump	$1,210 00	
Sending down castings	90 00	
		1,300 00
Pump room		1,257 40
Putting in pipe		120 00
Estimated cost of pump compartment in shaft, 3x4		3,000 00
Total		$20,012 47

Time of erecting, 21 weeks.

Comparing the two Vulcan pumps, it will be noted that, in the case of the Cornish pump, the displacement per minute was 727.5 gallons and, in the case of the Worthington, 697.7 gallons. As the flow of water was practically constant, these figures prove that the leakage through the valves of the former pump was 29.8 gallons per minute greater than in the latter. After the table had been prepared an attempt was made to determine the actual slip by stopping the pumps and closely timing the rise of water between two given points in the pump cistern. This observation gave 676.6 gallons as the flow of water per minute, or 6.8 per cent, and 3 percent less than the respective displacements of the Cornish and Worthington pumps. In the table the slip had been assumed to be nine and five per cent.

The Aragon pump has been running continually since October, 1890. It is a "Lehigh" pattern Worthington, having only one suction and one discharge valve at each end of the water cylinders. The plungers are somewhat unevenly worn, averaging now nine and three-fourths inches in diameter. The steam cylinders are covered but not steam-jacketed. In the construction of the pump, no allowance is made for packing the piston rod between the high and low pressure cylinders. To the latter is attached a Worthington independent condenser. The steam pipe is 660 feet long and four inches in diameter. The delivery pipe is eight-inch.

The compound condensing pump at the Pewabic mine has a Hughes steam end and Worthington water end, the Hughes water end having been exchanged for a Worthington of the "Lehigh" pattern. During the test which was made February 17th and lasted twenty-four hours, steam was led to the pump from two return tubular horizontal boilers through a four-inch steam pipe 862 feet in length. No expansion joints are used but the pipe is fastened rigidly to the shaft timbers, half way down in the shaft, and the expansion of the pipe is compensated for by swing joints, there being thirteen elbows in the whole run of pipe. The pipe is well covered, but not the cylinders. An independent condenser is attached to the pump. Two hundred feet of the delivery pipe is ten-inch and the balance twelve-inch.

The duty of the new Chapin pumping plant, of which we may expect a full description and a complete test in the future, is based upon records of the coal consumption and speed of engine from June, 1894, to January, 1895, inclusive, as follows:

	Pounds coal per hour.	Double strokes per minute.
June	689	5.06
July	584	4.63
August	566	4.55
September	591	4.45
October	578	4.36
November	579	4.13
December	558	4.02
January	535	3.92

The Chapin plant was designed to raise 3,000 gallons 1,500 feet, and is now doing less than twenty per cent of its ultimate capacity.

The flow of water into the Chapin mine has not increased very much during the last nine years. During the period covered by the above records it was 1,342 gallons per minute, while the records for the year 1886 show that it then averaged 1,176 gallons.

The record of baling given on the table was kept by representatives of the Hamilton Ore Co., and the Webster, Camp and Lane

Machine Co., and was kindly furnished by them. The balers were operated by a flat rope hoisting plant having two 40x72 inch Corliss engines. It was built by the Webster, Camp and Lane Machine Co.

I have been informed by Mr. J. T. Jones that before the closing down of the Hamilton mine the water was taken care of by this plant for a time of five months.

The data given in this paper are not sufficient to demonstrate the superiority of any certain type of pumping machinery over others, and I do not wish that they should be thus used. Several of the recorded tests could not be made with desired exactness, and some of the plants are not fair representatives of their respective types. It is obvious that improvements can be made in most of them, and I am aware that such improvements are already in progress of introduction. We may therefore expect that future tests will give higher efficiencies.

It may be pointed out that in several instances the pumps work very much below their ultimate capacities, and I am decidedly of the opinion that pumping plants of too large dimensions are frequently erected. The consequence is not only that expenditures for equipment become unduly high, but also that the desired efficiency of plant cannot be obtained.

The writer is indebted to Messrs. Wm. Kelly, of Vulcan, James MacNaughton and E. F. Brown, of Iron Mountain, Mich., for ready assistance in the collection of data for this paper.

DISCUSSION.

MR. W. J. OLCOTT: Why do you estimate a leakage of three per cent on the Chapin and of five per cent on all the others.

MR. PER LARSSON: In the case of the Vulcan, Cornish and Worthington pumps you can readily see that there is quite a difference in my figures of "water displaced per minute." There must be a great deal more leakage in the case of the Cornish pump. By reducing the figures I have given for the Cornish pump nine per cent, I get 662 gallons per minute; by reducing the 697 gallons figured for the Worthington five per cent I also get 662 gallons. The reason I have allowed a less percentage of slip in the Chapin is the difference in the valve.

Mr. Wm. Kelly: Mr. Larsson has remarked that some of these tests were made under *ordinary* conditions. I think I may say in the case of the Vulcan that they were *very* ordinary conditions. In the first place the boilers used were not the ones with the best draught. The amount of coal does not represent the cost of operating the pump, because we were using wood.

Mr. W. J. Olcott: I want to ask Mr. Larsson if he has any explanation for the great discrepancy between the duty of the pump at the Aragon and that of the Worthington pump at the Vulcan.

Mr. Per Larsson: The pump at the Aragon has been working for four years, and the plungers are pretty well worn out, and it is a smaller pump than any of the other pumps.

Mr. F. P. Mills: I am a little surprised to see the low efficiency of the Cornish pump at the Vulcan. We have one which compares very well with the duty at the Chapin. Our pump has an 18″ cylinder and 60″ stroke. The pump makes five or six strokes per minute, and has a 14″ plunger. I do not remember the allowance for slip, but think it is about four per cent.

Mr. W. J. Olcott: I would like to ask Mr. Wm. C. Brown to explain the difference in the duties of the Worthington pumps.

Mr. Wm. C. Brown: It is found in building pumping engines of that character that there is a very great increase of duty in the larger engines for greater work, and then the coal used by the smaller pump was evidently not as good a quality as that used by the larger. Taking the coal into consideration, and the sizes and patterns of the engines, and the fact that one has a low duty cylinder jacket, there is just about the difference we would expect.

*ADDITIONAL PUMPING DATA.

Pumping Plants of the Cleveland Iron Mining Company, Ishpeming, Michigan.†

This company has two pumping plants which were tested for efficiency by a mechanical engineer and the results of the tests are given below. One plant consisted of a Cornish pump with fourteen-inch poles, nine feet stroke, and geared with a single reduction of eight to one. The engine is of the Corliss type 18″ x 60″, and is connected to a Bulkley condenser which is supplied from the column pipe.

The other plant is a good, double-acting, duplex, compound, condensing pump, having high pressure cylinders fourteen inches in diameter and low pressure cylinders twenty-four inches in diameter.

The water plungers are six inches in diameter, and the stroke of steam pistons and plungers is twenty inches.

The tests lasted ten hours and great care was taken to insure accuracy.

Indicator cards were taken every forty minutes.

RESULTS FOR THE CORNISH PUMP.

Lift of Pump 660 feet. Speed, 4 to 6 revolutions per minute.

Average power from cards	71.109 H. P.
Water per indicated H. P. per hour	19 410 lbs.
Coal consumed per indicated H. P. per hour	2.539 "
Work done per one hundred pounds of coal consumed,	62,813,300 foot pounds.

RESULTS FOR THE DUPLEX, COMPOUND, CONDENSING PUMP.

Lift 825 feet. Averagc speed 12.2 revolutions per minute.

Average power from cards	26.55 H. P.
Water per indicated H. P. per hour	95.93 lbs.
Coal consumed per indicated H. P. per hour	13.37 "
Work done per one hundred pounds of coal consumed,	12,725,200 foot pounds.

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* Sent to the Secretary since the meeting.

† Mr. F. P. Mills furnished the data for this Company.

THE NEW PUMPING PLANT OF THE STIRLING IRON AND ZINC CO., NEW JERSEY,

*With extracts from the Official Report of a Duty Test of the same.**

BY J. PARKE CHANNING.

In February, through the courtesy of Mr. J. A. Van Mater, the superintendent of the Stirling Iron and Zinc Co., at Franklin Furnace, N. J., I was enabled to inspect a direct acting steam pump in their zinc mine. The mine is a new one opened up by a three compartment shaft some 700 feet deep. The shaft was sunk to a depth of 600 feet without any difficulty when a sudden inflow of water at the rate of 1,500 gallons per minute drowned out the shaft. After fourteen months work and the expenditure of $75,000 the water was controlled and sinking resumed.

The inflow diminished to 600 gallons per minute, of which 400 came in at the 600-foot level, and the other 200 gallons from a point forty feet further up the shaft. The water was handled with the Cameron sinking pumps used in recovering the shaft, they being arranged in series, with average lifts of 200 feet and intermediate sumps.

These Cameron pumps, while unexcelled for sinking, were of course, expensive to operate as station pumps, and after considerable investigation of the subject, Mr. Van Mater put in a triple-expansion duplex Worthington pump at the 600-foot station, to elevate the water in one lift.

The high pressure cylinders are thirteen inches in diameter, the intermediates twenty-one inches, and the low pressures thirty-four inches. The water end is of the "Lehigh" pattern with nine and one-half inch plungers. The stroke is twenty-four inches. The pump is designed to handle 800 gallons per minute against 600 feet head, with a boiler pressure of 100 pounds, and the water end is strong enough to permit the pump being dropped down to a lower level and operated with smaller plungers.

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* **Mr. J. A. Van Mater furnished the report of the duty tests after Mr. Channing had prepared his description.—*Secretary.***

When the pump was put in it was expected that the 200 gallons flow from the 560-foot level would continue, and so an elevated condenser, similar to a Bulkley, was put in to take care of the exhaust. A small air pump was also erected to keep the air and vapor out of the elevated condenser. During the winter this water diminished in flow, and in order to keep the condenser going it became necessary to bleed the column. At the time of my visit a surface condenser was being constructed, which was to be placed in the suction of the pump to replace the elevated condenser. This will effect a very material saving over the present method, and will probably give an increase of ten per cent efficiency over an ordinary independent condenser.

Among the other novelties in the pump may be mentioned the method of connecting the pistons so that each of the cylinders may be internally examined, the use of cut-off valves on the high pressure cylinders, and the placing of all valve chests on the under side of the cylinders to prevent the entrance of water into them. The cut-off valves, which are variable, were set at the time of my visit to cut off at about eleven inches. The result was very pleasing, the pump coming to a gentle stop without any noise.

The intermediate and the low pressure cylinders were steam-jacketed, and all cylinders lagged and covered with sheet iron. The steam pipe down the shaft was exceptionally well lagged, although rather too large for the new pump. It was provided with an ample separator, and the separator and the jackets with traps.

The total cost of this plant, including pipes from boilers and the preparation of the station, but not the cost of the boilers, was about $10,000, and the estimated saving per day in operating is $18 over the old non-expansive pumps.

The pump was put in under a guarantee of a duty of 75,000,000 foot pounds per 1,000 pounds of dry steam, delivered at the throttle. From the preliminary tests that Mr. Van Mater has made and shown me, it seems quite likely that the pump, even with its present low supply of water to handle (400 gallons), will develop a duty of from fifty to sixty millions foot pounds per 100 pounds of fuel.

Extracts from the Official Report of the Duty Test.

The steam supplied for trial was generated in one of the 66″ x 18 ft. horizontal return tubular boilers in a battery of boilers near the head of the mine shaft, and was conducted from the same in covered seven-inch steam pipe running horizontally in the open air from the boiler house to the mine shaft, a distance of 208 feet and thence through the up-cast compartment of the shaft to the separator in the pumping station, making a total distance of 800 feet from boilers to pumping engine.

The water caught by the separator is regularly discharged from the same by a Nason trap into the main cistern below the pumping engine.

The amount of water thus discharged from the separator during the trial was caught and measured before discharging it into the main suction cistern.

After passing the separator the steam is conveyed to the pumping engine and air pump by two and one-half inch covered pipe, a distance of fifteen feet.

Calorimeter connection was made in this pipe near the pumping engine for the purpose of determining the quality of the steam. The sample showed only a small fraction of one per cent of entrained water when the pump was supplied with the same pressure of steam and run at the same speed as during the trials. The steam supplied the pumping engine during the trials is therefore assumed in the calculations to be devoid of moisture.

Water of condensation from the low pressure cylinder jackets and from the surface condenser was caught separately and measured, i.e., the water resulting from the condensation of exhaust steam from the pumping engine and the independent air pump, both ordinarily discharged by Nason traps into the main suction cistern, was separately caught and measured before being so discharged.

The pumping engine takes its suction from the main cistern, the level in which is ordinarily carried eight feet to ten feet below the centers of the pump plungers. On the day of trial the drainage flow into the cistern was such that a constant level could be maintained with the pumping engine running at rather less than fourteen revolutions per minute.

The contract trial of the pumping engine, which required a speed of twenty-eight revolutions per minute, could not therefore be made of greater duration than one hour. The contract trial began with the cistern filled to the highest point practicable, i. e., with a lift of five feet, and ended with a lift of thirteen feet, the average lift being about nine feet.

It was agreed with Mr. Brown, the representative of the Worthington Company, that an allowance of five pounds per square inch should be made in the readings of the discharge gauge in compensation for the average level of the cistern below the pressure gauge.

The pumping engine discharges through a ninety-degree bend of three feet radius to an eight-inch check valve over the pumping engine, and thence through an eight-inch pipe and another ninety-degree bend of three feet radius up the shaft to a gooseneck at the shaft head.

A preliminary trial of one hour was made with the pumping engine running at about half speed.

DUTY TRIAL.

Preliminary Run at Half Speed. May 3, 1895, 11 to 12 A. M.
Duration of Trial, 60 minutes.

Average steam pressure at pump, per gauge, 95 lbs., corrected	87 lbs.
" water pressure at pump, per gauge, 260 lbs., corrected	249½ "
" " " " " allowing 5 lbs as agreed	254½ "
" vacuum at pump, per gauge, 26	26 "
" speed of air pump, revolutions per minute	28 rev.
Total revolutions of pumping engine, per counter	804
Length of stroke of 4 plungers, each 9½″ diameter	2 ft.
Total plunger travel=2′x 4 x 804=	6,432 "

Total number ft. lbs. resistance overcome by water plungers=6,432′x 70.882 sq. inches x 254½ lbs.=116,039,519.04 foot lbs.

Dry steam used at 87 lbs. corrected pressure.

Water of condensation from exhaust of pumping engine and air pump	1,521.66 lbs.
Water of condensation trapped from jackets	147.87 "
Total	1,669.53 lbs.

Foot lbs. of duty per 100 lbs. of coal on a basis of evaporation of 10 lbs of water per 1 lb. of coal $\frac{116,039,519.04}{1,669.53}$x10x100=69,502,506 ft. lbs. duty.

CONTRACT DUTY TRIAL.

May 3, 1895, 3.06 to 4.06 P. M. Duration of Trial, 60 Minutes.

Average steam pressure at pump, per gauge, 98 lbs., corrected..	90	lbs.
" water pressure at pump, per gauge, 260 lbs., corrected..	249½	"
" " " allowing 5 lbs, as agreed..................	254½	"
" vacuum " at pump, per gauge 24⅛..................	24⅛	"
" speed of air pump, revolutions per minute 28...........	28	"

Speed of pumping engine held at 28 revolutions per minute.

Total revolutions of pumping engines, 28 x 60=1,680.

Total plunger travel=2′x 4 x 1,680=13,440 feet.

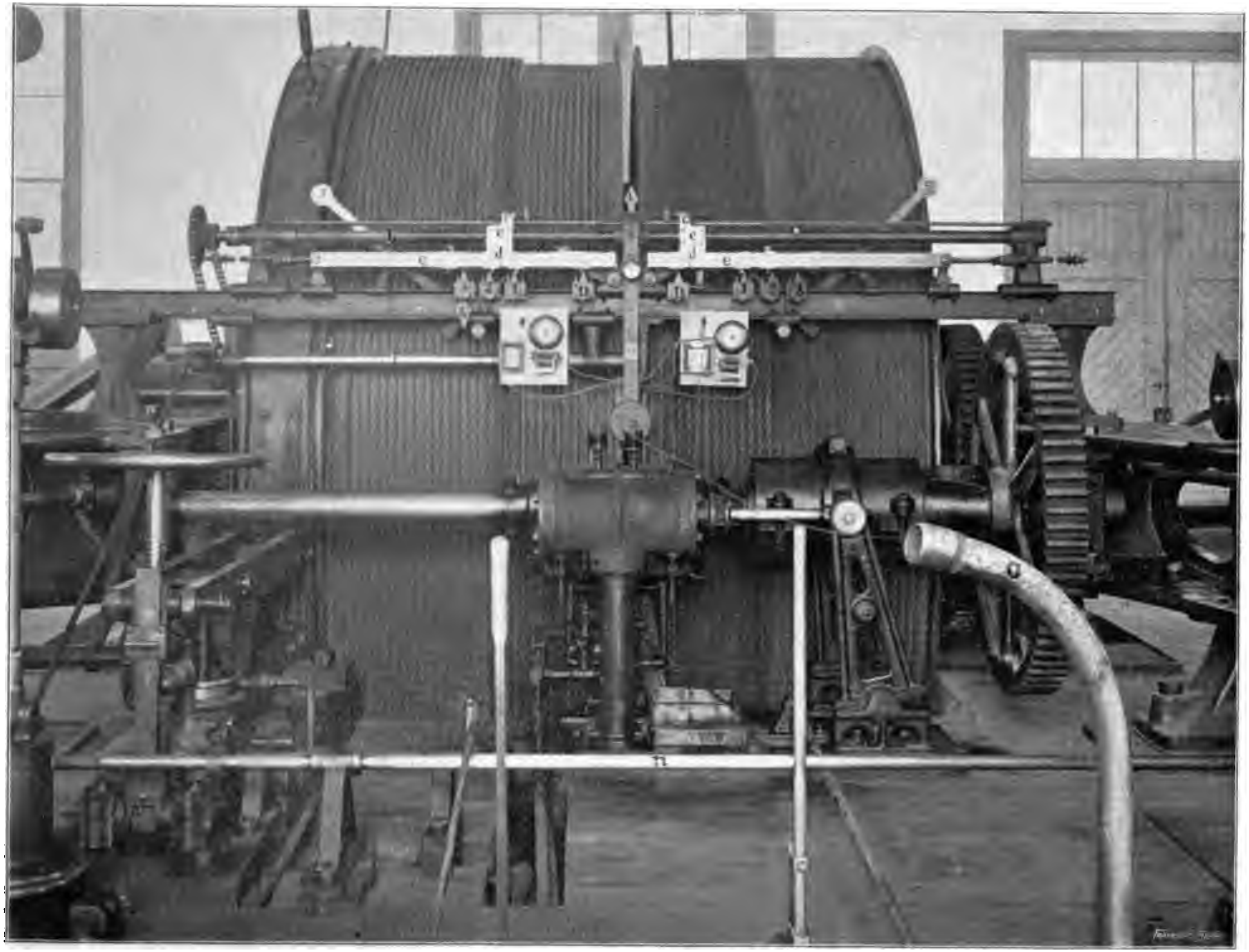
Total number foot lbs. resistance overcome by water plungers=13,440 ft. x 70.882 sq. in. x 254½ lbs. = 242,470,636.80 foot lbs.

Dry steam used at 90 lbs. corrected pressure.

Water of condensation from exhaust of pumping engines and air pump..	2,899.8 lbs.
Water of condensation trapped from jackets..................	197.1 "
Total..	3,096.9 lbs.

Foot lbs. of duty per 100 lbs. coal on a basis of evaporation of 10 lbs. of water per lb. coal:

$$\frac{242,470,636.80}{3,096.9} \text{x}10\text{x}100 = 78,294,625 \text{ ft. lbs. duty.}$$



HOISTING PLANT, LAKE MINE, CLEVELAND IRON MINING CO.

THE HOISTING PLANT OF THE LAKE MINE.

Cleveland Iron Mining Company, Ishpeming, Michigan.

BY J. M. VICKERS.

The hoisting engines of the Cleveland Iron Mining Company's Lake Mine, Ishpeming, Mich., are of the cross-compound, condensing, steam-jacket type, with Corliss valves and Deane independent condenser. The hoisting plant was manufactured by the M. C. Bullock M'f'g Co., Chicago.

The cylinders are 20″ and 32″ by 48″ stroke, and are designed for a steam pressure of 125 pounds.

There are two drums directly connected, each 12 feet in diameter by 42 inches face, and with a capacity of 1,256 feet of one and one-fourth inch rope.

The right-hand drum is securely keyed to the engine shaft, and the left-hand drum is secured to the right drum by bolts through the inner spider arms, with the heads of these bolts in an annular groove in the casting which connects the inner arms of the right drum. The slacking of these bolts, and also of the bolts which clamp the hubs of the left drum to the shaft, will permit the left drum being held by the brake, which is connected therewith and the engines may then operate the right drum for any adjustment.

One brake operates for both drums, for in hoisting, both drums are securely bolted together.

The skips work in balance, and any change in their relative positions for different levels, or for change of rope length, is made by a corresponding change of the two drums.

The reversing of the engines is effected by two steam cylinders, which operate a shaft through the medium of a compound nut and screw, causing the partial rotation of the shaft.

The reversing shaft is directly in front of the drums and with proper connecting rods, operates the wrist plates which give the valves movement.

An intercepting valve is placed between the receiver and the low pressure cylinder, the office of which is to furnish high pressure steam for the low pressure cylinder when the supply is exhausted from the receiver. This is effected by a pipe connection with the intercepting valve chamber, which supplies high pressure steam and operates the intercepting valve automatically.

The brake may be operated by hand, through the medium of a hand wheel and screw, but for general service there is a cylinder with a single acting piston, in which water is used under a pressure of about seventy pounds.

A receiver ten feet long by three feet diameter, is first filled with air under pressure; water is then pumped into the receiver until such pressure is attained as is found by practice to be the most satisfactory. A pipe connects this receiver at the bottom with the brake cylinder, with a proper operating valve between. The water which is exhausted from the brake cylinder is conducted by a pipe to a small receiver in connection with a small duplex pump. In the pump receiver is a float which by the inflow of water is raised. The raising of the float opens the throttle of the pumps, starting the pumps, and returning the exhausted water to the large receiver. The water, to which soap is added for lubrication and preventing rust, is used indefinitely.

The brake piston packing is a cup-leather, and is very satisfactory for freedom from leakage and for durability.

The indicator is of a new style, and is located directly in front of the brakeman, and about five feet above the floor and as close to the drums as is practicable. It is horizontal and is supported at each end by the engine bed, through the medium of a four-inch I beam "a" (see plate), to which the indicator proper is attached.

In suitable bearings on the upper side of the I beam a screw "b" about two inches in diameter is located. This screw has a thread of one-half inch pitch. At the left hand end as you face the drums, a sixteen sprocket wheel is keyed. A thirty-six sprocket wheel on the engine shaft drives the sixteen sprocket wheel through the medium of a link belt. On each side of the central bearing of the screw "b" there is a nut "c," "c" which carries a pointer "d," "d." These nuts, or pointers as they may be called, are carried back and fourth as the screw rotates by the action of the engine shaft.

The winding ropes are attached to the drums at their outer edges so that when wound onto either drum and the skip is on the dump the indicator pointer "c" will be at the inner end of travel or next to the central bearing.

Attached to the I beam "a" is a series of targets, "3," "2," "1," "D," "D," "1," "2," "3," which may be placed at such points as will be located by the pointers "c," for the dump and the various levels. Attached to the lower side of each indicator nut is a latch which is pivoted at one end, the free end being toward the central bearing, and which has a limited amount of drop.

Between the indicator screw "b" and the I beam "a" on each side of the central bearing, there is a swinging frame, "e," "e" on which there are as many hard steel blocks "f," "f" as there are dump and level targets.

The steel blocks, "f" project above the swinging frame about 1-8", and the construction is such that they may be readily removed for making adjustments.

Attached to the shafts operated by the swinging frame "e," there are levers and connecting rods which operate quick motion indicators "g," "g," with arms about two feet long. These arms operate towards a target, "h," on the central bearing, and are made to operate by the latch on the under side of the indicator nut engaging with the steel blocks "f" in the swinging frames. Two revolutions of the drums make a full movement of the arm. The release at the central bearing target "h" is effected by the endwise movement of the swinging frame "e," which lowers the blocks until the latches release them, when spiral springs "i" "i," connected with the frame, cause a quick return of the arms. A suitable mechanism in connection with the engine governor prevents the engagement of the latches with the swinging frame blocks, when the engines are running under the control of the governor.

Distinctive features claimed for this indicator are, a quick motion indicator for each level as well as the dump, and a view of the entire indicator at all times.

The targets, except for the quick motion arms, have a double face "h'," the outer one being hinged at the lower side and so balanced as to drop by the release of a catch, which is operated by an electro-magnet attached to the back of the targets. The inner and outer faces of each target have marked on them the same letter or number, but the faces are different colors, for distinction. When a train of loads comes to the shaft in a certain level, a signal is sent over a wire leading to the target corresponding to that level, which causes the outer face to drop.

A vertical projection "c′," of the top of the indicator nut "c," carries a horizontal screw "j," which is used in connection with the automatic stop.

Located centrally and vertically on the face of the indicator is a lever "k," pivoted about one-third of its length from the top, and made to swing to the right or left. The top of the lever is in line with screw "j," in the top of the indicator nut "c." The lower end of this vertical lever has a projection which engages with a projection from the horizontal shaft "l," under the indicator, and parallel thereto.

The left-hand end of this shaft has a weighted lever, together with a lever which carries a connection "m," with the governor shaft "n," which in turn connects the two engines.

The governor shaft is so connected that with sufficient movement the brake cylinder valve will be opened and the steam valves of the engines tripped. In practice the screws "j," at the top of the indicator nuts are adjusted to ⅛ in. clearance from the side of the vertical lever "k," when the skip is in the dump. If the skip were overhauled enough to make ¼ in. travel of the indicator nut, the vertical lever "k," would be released from the engagement of the projection on the horizontal shaft "l," and the weighted arm would cause the shaft to partially rotate, and thereby cause the governor shaft "n," to release the steam valves, which in turn would shut off the steam from the engines and open the valve to the brake cylinder and put on the brake.

As one revolution of the drum will move the indicator nut 1⅛ inches it will be seen that the automatic stop will be operated in a little more than 8 ft. travel of the rope beyond the dump.

The brakeman or operator is stationed between the cylinders, facing the drums and indicator, with the brake lever at his left hand and the operating lever at his right hand.

The operating lever controls the reversing gear as well as the steam for hoisting.

When the lever is in a vertical position, all the steam is shut off. A slight movement forward or back will admit steam to the reverse cylinders, and a still further movement of the lever will admit steam to the high pressure cylinder of the hoisting engines. The operating or handling of the hoist requires very little labor.

The governor speed is thirty-five revolutions per minute, giving about 1,320 feet rope travel per minute.

No gates are used in the shaft.

The angle of the shaft is 50°.

The skip load is 3¼ tons.

From the dump to 1st level is 310 feet.

From the dump to 2d level is 440 feet.

From the dump to 3d level is 570 feet.

Hoisting has been done from the 2d and 3d levels at the rate of twenty-six skips in twenty-five minutes.

Diagrams from the engines under current working conditions give 263.58 H. P., with a credit to the condenser of twenty-one per cent.

The boilers now in use limit the steam pressure to 100 pounds, but new boilers now being put in will allow 125 pounds pressure.

THE RELATION OF THE VEIN AT THE CENTRAL MINE, KEWEENAW POINT, TO THE KEARSARGE CONGLOMERATE.

BY L. L. HUBBARD.

The veins that occur on Keweenaw Point belong largely in one system whose origin may reasonably be ascribed to some common cause, whatever that cause may have been. They are exposed and hence their occurrence is presumed to be confined, principally, between T. 57, R. 32, and the northeast extremity of the point. The copper-bearing formation between these limits strikes from about N. 33° E, or a little less, at the first named locality to somewhat south of east at the last, and the veins with few exceptions, strike W. of N., or nearly at right angles with the formation.*

My object in this paper is not to give a general description of these veins, for only a few of them have been exploited to any considerable extent, and the records of even these are meager and to a great extent inaccessible. I propose rather to give several diagrams of the vein at the Central mine and in connection with them to point out some facts and conclusions of more than ordinary interest. The observations on which my remarks and diagrams are founded, were made during several visits underground at the mine in the autumn of 1894.

The Central mining Company began operations in 1854 on a vein (the "East" vein) at the bottom of an "ancient excavation about 600 feet south of the crystalline trap," † opened under the direction of John Robingson "(which ancient excavation had been discovered some weeks before by Mr. Slawson), in which was found a mass of pure copper sticking firmly in a vein bearing a little east by south."*

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* Marvine divides the veins of Keweenaw Point into two systems, one of which trends N. 15° to 25° W., the other about N. 16° E., and both probably dipping easterly. Geol. Survey of Mich. Vol. 1, Pt. II, p. 114.

† First Annual Report of the Directors of the Central Mining Co., 1855, p. 4.

This is in section 23, T. 58, R. 31, and is about eighteen miles northeast of Calumet, or about four miles easterly from the Phœnix mine at Eagle River. The Cliff, Phœnix and Central veins carried mass copper, and during the early history of this district contributed largely to give Keweenaw Point its celebrity as a mineral producer.

For fifty years the Central mine has been worked by means of three vertical shafts and one inclined shaft, and the deepest shaft, No. 2, is now down to the thirty-second level—2,661.8 feet. This measurement was made (by the mine officials) on the skip rope, and is about forty-six feet less than the depth as scaled from the working map of the mine. In plate II the distances between levels from the surface down to the twenty-seventh level show a proportional reduction from those of the working map (2.42 per cent.) to correspond with this determination. From the twenty-seventh to the thirty-second level, hundred-foot lifts have been assumed to be correct.

Thus far there have been four conglomerate beds encountered in the Central,—the Allouez conglomerate at the extreme north end of the mine, the Houghton next below it, then the Calumet and Hecla, and lastly the Kearsarge. My reasons for this identification may be gathered from the following table, some of the figures in which appear in the last annual proceedings of this body.

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* First Annual Report of the Directors of the Central Mining Company, 1855, p. 4.

VERTICAL DISTANCES BETWEEN CONGLOMERATES.

	KEARSARGE.	CAL. AND HECLA.	HOUGHTON.	ALLOUEZ.	Totals.
At Peninsula Mine		684		427	
			1,111.5		
Calumet	930		1,309		2,239
Kearsarge Mine	1,064		1,432		2,496
		814		660	
Central Mine	1,125				2,599
			1,474		

(Figures subject to revision.)

If the uppermost of the four conglomerates, the one at the base of the "greenstone" range is the Allouez (at Eagle River, called "the slide"), as is generally conceded we see that the widening of the beds from Portage Lake northeastwardly continues, not at the same rate, it is true, even beyond Eagle River, to which point Marvine investigated and established it. The culmination of this widening may, of course, lie west of the Central mine. An additional ground for the belief that the lowest of the conglomerate beds is the Kearsarge, lies in the fact that it is flanked by heavy beds of trap, precisely as is the Kearsarge at Calumet, although, in the latter case, these beds are much thicker than at the Central.*

The Kearsarge conglomerate at the Calumet and Hecla mine is sixty-four feet thick, and is there overlain by an amygdaloid thirteen feet thick, which at the Central mine is replaced by a breccia, as will be more fully explained hereafter.

We see also that the Houghton conglomerate, absent at Calumet, has reappeared here, showing that at the time of its deposition, a part of Keweenaw Point between the Peninsula mine and the Central mine was probably above water.

The Calumet and Hecla conglomerate in the Central mine is, according to the mine reports, only from two to four feet thick, and is cupriferous along the vein—at one place—as far as forty feet laterally from it.

The chief interest, both from a geological standpoint and from that of the miner, centers about the lowest or Kearsarge conglomerate. The east vein runs down *to* this bed, but apparently not *through* it. This is true of all the levels by which the conglomerate was cut, from the 28th to the 32nd inclusive. In all of these levels except at the 31st, cross-cuts or drifts were run under the conglomerate in search of the downward extension of the vein. Some of them encountered narrow seams of laumonite or slips in the country rock, but, except the "west" vein, nothing was found that carried copper in paying quantities or that approached in size or general character to the vein above the conglomerate. Plate I

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*See cross-section of Calumet and Hecla mine, in proceedings of Lake Superior Mining Institute for 1894, and in Vol. V., Geol. Survey of Michigan, 1895.

(made by the mine officials) shows the courses of these levels and a horizontal projection of the conglomerate in them.

Plate II shows a section through the vein and through shaft No. 2 in the direction N. 76° 53′ E., i. e., at right angles to the strike of the vein at that point,—N. 13° 07′ W. The strike of the vein, as before remarked, and its dip—eastward—are characteristics which it shares in common with most of the veins on Keweenaw Point.* Its width varies between a few inches and twenty-five feet. Two bulges are shown in the drawing as they exist, according to the mine reports, near the shaft at the 14th and 16th levels respectively. The other parts of the vein along this line, below the 19th level, are not drawn to actual measurement, as no records were available to show their exact width.

Just above the 30th level the shaft penetrated, so I am told, a bed of brecciated matter or veinstuff coming in from the west, which went almost vertically through the conglomerate and continued indefinitely below it, dipping slightly to the east. This vein, called the "west" vein, was followed by the miners for some distance south and contained some copper. The coming in of this vein on the *west* side of the shaft and the fact that at the surface a second vein outcrops west of the shaft, at a distance west of the east vein, about equal to the distance between them at this level, seemed to warrant the conclusion in the miners' minds that the two veins, the east vein and the west vein, had no connection, and that the east vein, with all its riches, had simply run out.

An examination of the levels, from the 28th to the 31st, revealed the following facts (the 32d level, at the time of my visit, being filled with water): The hanging of the conglomerate is at most points, where accessible, well marked and shows a hard and even surface. This bed is composed largely of pebbles of quartz-porphyry cemented by finer material of the same nature, the lower part of the bed in places being of so fine a texture as to resemble a solid quartz-porphyry. Overlying the conglomerate is a stratum of epidotic, calcitic and prehnitic rock, containing more or less free quartz. This stratum, while somewhat irregular, is in many places four feet thick. At several points it is recognized as altered conglomerate, some of its pebbles still showing plainly their rounded forms. The altered conglomerate is in turn capped by a bed of fine breccia, three feet or more thick, the lower seven inches of which is fluccan, more or less wet and muddy. Above the breccia is a thick bed of trap, which is, near the contact, much broken and very chloritic.

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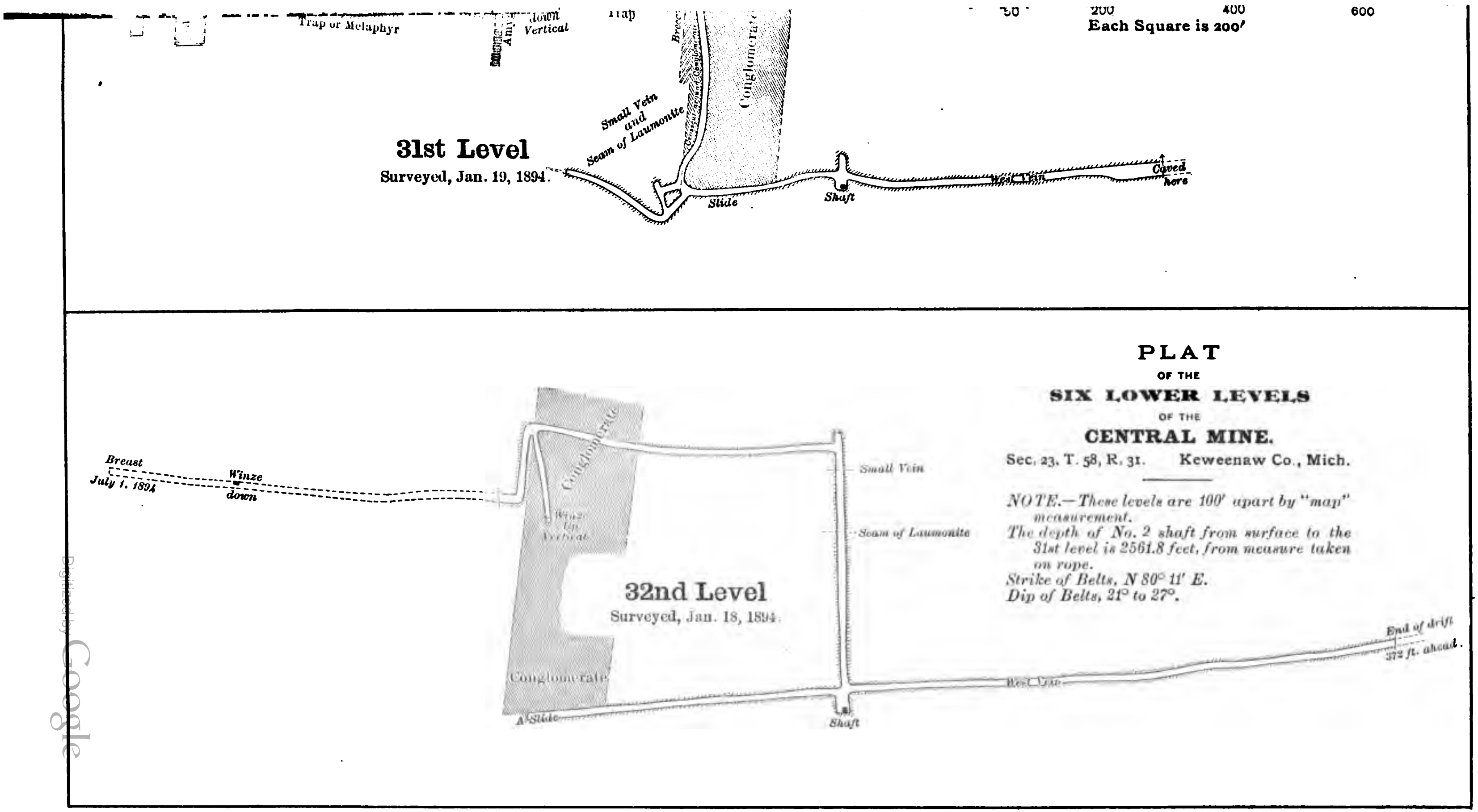
* Geological Survey of Mich. Vol. I, Pt. II, p. 114.

The presence of the breccia led at once to the supposition that there had been motion along the top of the conglomerate, and our efforts were thereupon directed to determine, if possible, the actual or at least the relative amount of motion on each side of each of the two veins.

In the west vein at the 31st level, north of the shaft, the rocks were in part so much slickensided and altered that the amount of displacement on the two sides of the level could not be measured. It was reasonably certain, however, that a bed of trap under the conglomerate was somewhat lower on the west side than the corresponding bed on the east side, and that the conglomerate, where exposed in a cross-cut west near the north end of the west level, was also apparently below the line of the hanging of the conglomerate on the opposite side of the same level. Another reason for supposing the throw to be downward on the west side of the west vein is seen at the 30th level at the south side of the shaft. The level here had caved in, but the conglomerate was flanked on the west by a nearly vertical bed of breccia five feet thick (see Plate III , the same bed that was encountered by the miners in the shaft just above this level. West of the breccia is a bed of trap, exposed from the roof nearly to the floor of the level where it was covered by broken rock. If the throw of the west side of the west vein here were upward, the amount of the throw would be twenty-five feet or more, and this would be irreconcilable with the relative position of the beds in the level next below. The throw of the west side, at the shaft, is probably *downward*, and is at least seven feet, and if the altered conglomerate and breccia above it exist west of the vein, the throw is more than seven feet.

The east vein was next visited, and in the 30th and 31st levels north of the conglomerate, near the center of a thick bed of trap, were found bands from one to two feet thick of a coarsely crystalline feldspathic rock, those on the west side being thirty-two feet further north than those on the east side. The breccia bed over the altered conglomerate exists also *east* of the east vein, so that the conclusion is irresistible that there has been a large amount of sliding along the hanging of the conglomerate of all the overlying country rock on *each side* of the east vein, and a further displacement (of at least thirty-two feet) towards the north, of that portion of this country rock that lies on the *west side* of the same vein. If the above mentioned bands in the trap are conformable with the dip of the beds, which they appeared to be, although we did not measure their dip, the movement that caused the latter displacement could not have taken place in a plane parallel with the dip, as well as in the same direction in that plane as the former movement, for, if it had, the relative positions of the bands on the opposite sides of the vein would not have changed. The country rock, therefore, above the conglomerate, between the E. and W. veins has moved to the north, thus producing along the W. vein the relations of a reverse fault, and along the E. vein those of a normal fault.

If now, gravity was the principal factor in the sliding of the 2,500 feet, and more, of rock above the conglomerate (and we know of nothing to make this hypothesis improbable), we may fairly assume that this sliding took place along the steepest plane possible on the top of the conglomerate, i. e., in the direction of the dip,—or at right angles to the strike. The latter is N. 80° 11′ E., and the vertical plane through which the line of dip passes runs therefore, N. 9° 49′ W. The strike of the vein is N. 13° 07′ W. The entire formation above the conglomerate, i. e.. on each side of the east vein, may be assumed then, to have slid in the direction N. 9° 49′ W., or thereabouts, while that part of the formation west of the east vein slid further north *along the vein*, or N. 13° 07′ W., giving rise to the fault of thirty-two feet above noted. It is only by some such hypothesis that we can account for the latter. This general movement of the entire formation in a direction, however slight, towards the east, away from the line of the vein, may well be the cause also, of the warping or folding-under of the vein towards the west, where it joins the slide-plane, i. e.,



PLAT
OF THE
SIX LOWER LEVELS
OF THE
CENTRAL MINE.

Sec. 23, T. 58, R. 31. Keweenaw Co., Mich.

NOTE.—These levels are 100′ apart by "map" measurement.

The depth of No. 2 shaft from surface to the 31st level is 2561.8 feet, from measure taken on rope.

Strike of Belts, N 80° 11′ E.

Dip of Belts, 21° to 27°.

Drawn by **Theo. Dengler**, E. M., Feb., 1895, from a survey in Jan., 1894.

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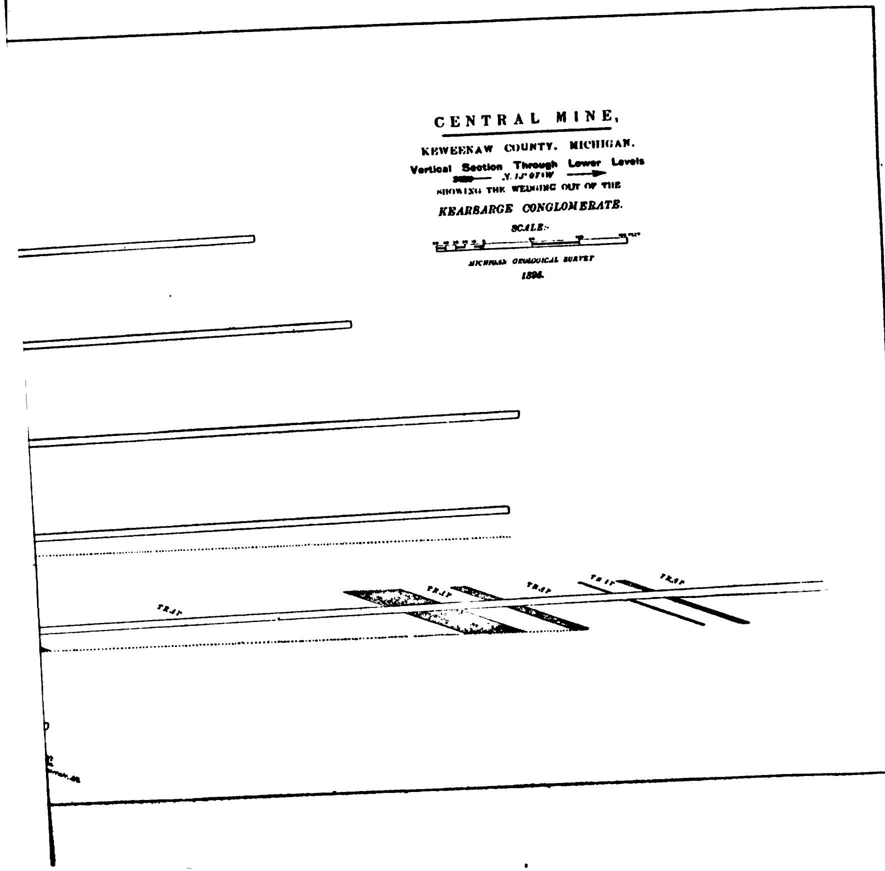

CENTRAL MINE,

KEWEENAW COUNTY, MICHIGAN.

Vertical Section Through Lower Levels

N. 15° 07' W

SHOWING THE WEDGING OUT OF THE

KEARSARGE CONGLOMERATE.

SCALE:-

MICHIGAN GEOLOGICAL SURVEY

1895.

the breccia over the conglomerate (plates II and III). This breccia and the altered conglomerate under it are in places quite cupriferous.

These considerations lead us naturally to the question "may not the west vein have been originally the downward continuation of the east vein, the latter having been faulted by the sliding just explained, and may not the supposed extension upwards of the west vein *above* the conglomerate at the 30th level be merely a coincidence? Such a conclusion is, indeed, supported by the fact that this connection between what are supposed to be the upper and lower parts of the west vein at the 30th level, does not seem to exist above the lower part of that vein where it penetrates to the hanging of the conglomerate in the 31st level. This absence of the vein *above* the conglomerate at this point is even more strongly in favor of the original continuity of the east and west veins, for while a fissure extending from the surface downward might happen to wedge out at some particular bed, however steeply inclined, it is highly improbable that we should find an independent fissure of the character and composition of the west vein, beginning 2,500 feet below the surface, and thence extending downward, unless, indeed, said fissure was formed and filled before the laying down of the overlying beds. The breccia encountered in the shaft just above the 30th level may be a part of the bed above the conglomerate, or it may, in fact, belong to the vein visible on the west at the surface, which might naturally be assumed to have shared in the general north-by-east movement of the country rock.*

From the facts above given it seems reasonable to suppose that the forces that produced the fissure along the east vein either failed to break through the conglomerate at all, or, what is more likely, broke through it at some point or points now removed from the vein, possibly along the line of the west vein, as above suggested. The breccia and the altered conglomerate formed good receptacles for the deposit of copper, and whether the east and west veins were originally one continuous undisturbed vein, or were formed approximately in their present relative positions are questions of subordinate interest to the miner, who, whatever their history, now sees in them parts of one productive system.

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*The exact status of the supposed extension of the west vein upwards above the conglomerate cannot at present be ascertained, for the only point in the mine at which it has been exposed is in the shaft, as above stated.

Geologically, one of the interesting points in this connection is the fact that we appear to have, along this Kearsarge conglomerate, the edge of the basin in which it was laid down.‡ An inspection of Plate IV shows the abrupt thinning out of the conglomerate, which at the 32nd and 31st levels is about fifty-seven feet thick, at the 30th about thirty feet, at the 29th about six feet, and at the 28th about one foot. The 27th level south was caved in, so that the upward extension of the slide could not be examined.

Pumpelly published a cross-section of the Central mine from the 14th level to the surface.* This was derived from the working plan of the mine. It makes the dip of the beds under the Houghton conglomerate flatten out from 25° 49′, or upwards, at the south or higher ends of the beds, to 23° 16′ along their northern or lower ends. Our measurements and the computations deduced from them, except for Plate II, as above stated, were taken from a survey of the lower levels by Mr. Theo. Dengler, the engineer of the Atlantic mine (Plate I). They make the apparent dip (in a vertical plane that differs by 3° 18′ from a vertical plane at right angles with the line of strike) between the 28th and 29th levels 26° 54′, between the 31st and 32nd levels 20° 48′, and the average dip between the 29th and 31st levels, 23° 34′. The fact of a curvature of the beds below the Houghton conglomerate seems thus to be confirmed. The strike as measured on the Kearsarge conglomerate is N. 80° 11′ E.

The following facts seem, therefore, to be fairly established:

The identification of the Kearsarge conglomerate.

A slight thickening of the formation south of the "greenstone" northeastwardly from Calumet.

A northerly movement or sliding of the formation above the Kearsarge conglomerate.

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*Atlas Plate XXIII, Geol. Survey of Mich., Vol. I.

‡Another case of this kind is reported from the Hancock mine, in which the entire area of a small conglomerate was found included within the limits of the mine.

A similar additional movement between the two veins.

The merging of the east vein with the altered conglomerate and brecciated material above the Kearsarge conglomerate.

The probable identity of the east vein above the Kearsarge conglomerate with the west vein below it.

The location of the edge of the basin in which the Kearsarge conglomerate was laid down; and

The curvature of the hanging of the Kearsarge conglomerate.

NOTE—It is quite evident that if the east and west veins were originally one continuous vein, and if the former has been faulted into its present position, and if the motion along the top of the conglomerate, that produced this fault, took place in the direction of the dip plane, we have in hand the data to show an enormous movement of beds of the formation away from the fault line along the eastern sandstone, a movement that may have amounted to several thousand feet. The importance of this suggestion, in its bearing not only on the topography of Keweenaw Point, and the thickening of the beds of the copper-bearing rocks, but on the relations of the eastern and western sandstones, will at once be appreciated by the geologist. Its discussion, however, must be reserved for some future occasion.

OPEN-PIT MINING, WITH SPECIAL REFERENCE TO THE MESABI RANGE.

BY F. W. DENTON.

With the discovery on the Mesabi Range of large, more or less flattened masses of iron ore with, in many cases, shallow covering, interesting problems in mining have arisen. Not the least of these are the questions "How deep will it pay to strip?" and, after the stripping is completed, "How shall the ore be mined?"

Thus far two general methods of open-pit work have been adopted: One is to strip a comparatively large area and then, after having loosened the ore by blasting, to remove it by means of steam shovels, railway cars and locomotives. The other method is known as the "milling" system, or better, perhaps, as the "stripping-milling" system, and is a combination of surface and underground workings. The ore is stripped of its surface covering and then blastad into raises, which connect with drifts established fifty or sixty feet below the top of the ore. From the raises the ore is loaded into cars, trammed to a shaft and hoisted.

It is impossible to institute an accurate comparison of the two systems without exact figures of costs. It would seem, however, that the use of steam shovels has not the extended application of the milling system, or similar systems, but will be limited to favorable conditions, such as easy grades of approach and easy drainage. The ideal conditions for steam shovel work would occur should the ore lie in a side hill and dip in the same direction as the hill, with its lowest point at, or above, the level of the adjoining country. Under these conditions the grade favors the load and makes drainage easy. Such occurrences of the ore unfortunately are rare. As soon as it is necessary to carry the bottom of the pit below the level of the lowest ground adjoining, the expense of steam shovel work increases rapidly. Either heavy grades against the load must be used, or long and deep cuts made for approaches which do not uncover ore. When the conditions are such that only the top forty or fifty feet of ore favor steam shovel work, the stripping cost per ton must be high as the work must grow in area and not in depth, which calls for fresh stripping each year. Further, the Mesabi deposits are usually very wet, and when natural drainage is impossible, and the water level is reached, shafts must be sunk and perhaps small drifts run in the lower part of the deposit in order to drain the upper portion. This necessarily makes the drainage expense higher than in those systems in which the haulage levels are also used for drainage.

The steam shovel from a mechanical standpoint is a very uneconomical machine, and the cost of repairs is high. Locomotive expenses are increased rapidly by adverse grades, for a locomotive can haul on a two per cent grade only about one-eighth, and on a three per cent grade only about one-twelfth of what it can haul on a level. The economy of steam shovel mining depends upon keeping the shovel constantly at work, in order to maintain a large output. Delays, as we all know, are costly.

In the estimates of cost for this kind of mining that have appeared from time to time, the output of one steam shovel and one locomotive has been taken generally at 2,000 tons per day of ten hours. This calls for loading a twenty ton car every six minutes. Although this output has often been reached, and even surpassed, it must be considerably above the average for a season. There is usually insufficient tail room to maintain this output, and the delays due to breakages and accidents must further reduce it. Loading these so called "natural stock-piles" cannot be done under the conditions existing with artificial ones. When conditions are favorable there is perhaps no cheaper method of removing ore.

In the milling systems the work grows in depth, and after a given amount of stripping has been done, all of the ore uncovered may be removed before further stripping is necessary. When the block of ore has been mined, the pit thus made may be used as a place of deposit for the next stripping. It ought to be possible to utilize this advantage to materially reduce the cost of subsequent stripping, for the haul would be short, and by systematic methods, the bottom of the stripping could be dumped into the bottom of the pit, and gravity would thus be made to assist throughout the work.

In the work of removing ore under the milling system, shoveling is almost entirely avoided until the bottom layer is reached. Tramming is done under the most favorable conditions, and it is not improbable that even the present low cost of this work will be further reduced by utilizing gravity. The average dip of the ore formation is thought to be, at present, about ten degrees, with local variations up to twenty and thirty degrees. If, now, a little more money is spent in exploration, and the general shape of the ore body is determined in advance of mining work, the shafts can be located at the lowest points, and the main drifts run in the gulleys, or hollows, which are likely to exist, and parallel to such hollows or gulleys. With this location of shafts and drifts it may be possible, if the dip is as it is thought to be at present, to use self-acting inclines to carry the ore from the working faces to the shafts. If this is possible, not only would the cost of underground transportation be reduced, but the removal of the bottom layer of ore would be simplified. The one disadvantage of the milling system is, of course, the necessity of sinking shafts and putting in drifts and raises. The cost of this work per ton of ore obtained is, however, low, and when we remember that in many of the deposits proper drainage can only be obtained by a shaft and by drifts in the bottom of the ore, this disadvantage is of little importance.

Before entering upon a discussion of the merits of open-pit mining in general, compared with underground work, it may be of interest to refer to one or two examples of open-pit mining carried on elsewhere. Although much work of this character has been done in several mining regions of the United States, including our own, the conditions have been very different from those existing on the Mesabi.

The enormous deposits of iron ore and copper-bearing pyrite of Spain correspond very closely, in the conditions presented for mining, to those of the Mesabi. The following extract is from a paper by B. J. Forrest in the transactions of the N. E. Inst. M. E's., Vol. XXXIII, 1883–84, and refers to the iron deposits:

"The mines are invariably worked open-cast, or in quarries. Some of the larger quarries are worked in two or three lifts of from twelve to fourteen yards high. The base of the ore is attacked by driving a tunnel, or gallery underneath the floor of the mine, and wagons can thus be loaded direct from the faces. * * Jumper drills are generally used weighing on an average twenty-five to thirty pounds, and larger ones from 150 to 200 pounds, and are thirty feet long."

M. Haton de la Goupillière in his treatise upon exploitation of mines, and in the chapter devoted to open-pit mining, gives an example illustrating the combination of open-pit with underground mining. The mine cited is an iron mine in Algeria and is described as follows:

"The foot wall is an impermeable schist. The dip varies from fifteen to forty-five degrees. The hanging wall is a calcareous rock, sometimes replaced by a schist similar to that of the foot wall, but more tender. The deposit forms a continuous mass for 4,900 feet along the strike. Its thickness which has an average of sixteen feet reaches, and even surpasses forty-nine feet at the enlargements. The mineral is an intimate mixture of magnetite and hematite giving sixty per cent of iron in the blast furnace. The magnetic oxide tends to predominate in depth and near the limestone, becoming very hard. The mine is laid out for an annual production of 300,000 tons, but the fluctuation of the working population often lessens this amount. It is exploited at this time (1883) by both surface and underground work, the outputs being in the ratio of one (1) from underground to five (5) from the surface.

"The open works are conducted in upright steps. They are intimately connected with the interior, into which they discharge the mineral and water. The flow of water is about ninety to 130 gallons per minute with increases during the rainy seasons. It is raised by two pumps, with a third kept in reserve, located in a shaft 213 feet deep. The materials are thrown into raises walled up with masonry, and widened towards the bottom, from which the loading is done direct into the cars of the Bône railway. These last circulate in galleries laid out in the direction of the strike, with a development of 3,900 feet. The chief ones are located at four different levels; that of the sea, two lower stages at -49 feet and -115 feet, and a higher stage of +85 feet at the railroad level. The wagons which weigh five tons are received individually upon the cage of a great inclined plane having a counterpoise and a safety devise which lifts them to the railroad level. In establishing equilibrium between the two methods of attack it is necessary to consider:

"First. The cost of removing the covering, its depth, its natural slope, which is generally one of base to two of height and rarely reaches forty-five degrees.

"Second. The thickness of the mineral, the contents of a cubic meter in merchantable tons, and the cost of breaking the mineral, which varies with the hardness.

"In general it is admitted that one can remove two cubic meters of schist for one of mineral. One is urged to increase the depth, when the labor underground, more difficult than that of the surface, becomes scattered, or when the mineral becomes exceptionally hard. One is restrained, on the other hand, if movements of the banks are feared, or when the handling of the earth cannot be sufficiently rapid to avoid delay."

The same author gives the costs of underground and open-pit mining as determined at one of the mines at Rio Tinto as follows:

	Open Pit	Underground
Breaking, manual labor, superintendence and explosives	$0.154	$0.386
Sorting, loading, transportation	.232	.338
Maintenance of tools, rolling stock and road	.097	.145
Total	$0.483	$0.869
Removal of covering and waste	.193	
Total	$0.676	$0.868

In other kinds of mining, notably in coal mining, and quarrying, stripping has been carried to great depths. The conditions, however, are such as to make the difference in the cost of removal with and without stripping, much greater than in the case of iron mining. Callon states for coal mining, that theoretically when the thickness of the overburden is equal to the thickness of the coal multiplied by 2.7, it is a matter of indifference whether we adopt open or underground workings, and adds, "this result agrees very well with practical experience." In these computations Callon assumes the cost of removing a cubic yard of dirt to be fifteen cents, and the saving in the cost of mining after stripping to be forty cents per cubic yard of coal. A cubic yard of coal is assumed to contain three-quarters of a ton. Haton de la Goupillière gives an example in which a horizontal coal seam ninety feet thick, with a covering of schist of about twice the thickness of the coal, is stripped. The schist is first undermined by a series of drifts on top of the coal, and then the supporting pillars are blasted simultaneously, which results in breaking down the schist above.

COMPARISON OF OPEN-PIT WITH UNDERGROUND MINING.

Chief advantages of open-pit method:

1. There is less danger to the workmen from falls of roof and blasting, and the chances of fire are less.

2. Economy in mining due to (a) the possibility of using large stopes, and large blasts, and thus avoiding the narrow working places necessary in underground mining—an advantage which increases with the hardness of the ore. (b) The easier and better superintendence. (c) The saving of the cost of timbering. (d) The saving in the cost of tramming. (e) The small saving in the cost of lighting.

3. All of the ore can be mined with equal ease and absolute certainty, thus avoiding the loss of ore more or less great, which must always accompany underground work.

4. Saving of the expense of making stock-piles and subsequent loading.

5. As the output per man per day is increased anywhere from two to nine times, the increase in cost due to an increase in wages will be less.

6. If the ore requires sorting it can be done cheaper and better in daylight. Or, if thorough mixing is desired it can be done better in open-pit mining.

Chief disadvantages of the open-pit method:

1. The necessity of providing a place for the waste material removed. This has been a chief source of difficulty elsewhere, and no doubt will often be so on the Mesabi.

2. If masses of glacial drift, beds of sand, or quantities of unsalable ore are met with they must be handled. In underground work these deads could be left in place, or at least would not have to be handled.

3. The expenses of open-pit work increase rapidly with the depth of covering, while those accompanying underground work are independent of this depth, at least up to the point when stripping is no longer a possibility.

It is evident from a consideration of these advantages and disadvantages that as the ore bodies recede from the surface, a limit is soon reached at which they neutralize one another, and beyond which stripping ceases to be economical. In order to determine this limit it is necessary to assign definite values in dollars and cents to these advantages and disadvantages, so that we may know exactly how much may be spent for stripping. The problem, therefore is a very simple one in the abstract but a very difficult one practically, owing to the impossibility of determining in advance with certainty the cost of mining a given ore body with, and without, its covering.

Once this quantity is determined, the depth at which stripping should cease, will depend simply on the cost of the stripping per cubic yard, or other unit, and the amount of extra stripping necessary to give the banks safe slopes. Of the advantages of open pit mining just enumerated, No. 2, or the economy in mining, is by far the most important in a discussion of this kind. The other advantages and disadvantages will depend, more or less, upon the conditions surrounding each case, and their money values can be determined with considerable accuracy when the conditions are known.

By permission of the officers of the Minnesota Iron Co. I am able to announce one value for advantage No. 2 for Mesabi ores. This value has been deduced from a comparison of the costs at the Auburn and Norman mines, with those of the Canton.

All of these mines are on the Mesabi range.

The Canton is an underground mine and has been worked by the North of England system, the Nevada system, and to some extent by making large rooms next the covering of the ore, without timber.

The Auburn and the Norman mines have been worked under the milling system which has been described. These three mines have been accurately compared with regard to:

1. The cost of mining labor which includes all miners, trammers, timbermen, mine captains and foreman, skip tenders and underground laborers.
2. The cost of timber.
3. The cost of explosives.

All other expenses were assumed to be equal. Average wages were brought to a uniform standard of $1.50. The results show a difference of twenty-one and one-half cents per ton of 2,240 pounds in favor of the milling system. This difference is probably less than it will be in the future, because:

1. The Canton costs are low, as the mine may be said to have reached its prime, and considerable ore has been won in large openings. When pillars shall have been robbed, and the remaining ore mined by some caving method, the average costs for the whole deposit will be higher than those used in this comparison.
2. The cost of timber at the Canton has been low, owing to the quantity of work done without using timber.
3. The Auburn and Norman have been able to mine but little ore on account of the dull season, and, therefore, have had but very short runs in which the mines were producing all the ore that their equipments and forces were capable of producing.

The Auburn costs were computed from a single run of less than one month, with a product of 53,632 tons, and those of the Norman from two short runs in the months of August and September, during which the output was 27,058 tons. The Canton figures were the averages for six months and an output of 173,000 tons.

In addition, the introduction of new methods must always require a certain amount of time and practice in order to reach normal mining conditions. This practice the Norman and Auburn have hardly had.

Let us assume, however, 21.5 cents per ton to represent the value of advantage No. 2, and neglect all others, as well as the disadvantages; also let us assume that a cubic yard of ore will furnish two tons, and that there is no stripping for bank slopes. Then, with stripping at forty cents per cubic yard, we can afford to remove 1.07 yards of stripping for one of ore. In deep stripping, the proportion which goes to give the banks the proper slopes will be comparatively large for the first cut, and will depend not only on the natural slope of the material and the depth, but also upon the shape of the area excavated.

It will be less for a given area, material and depth, as the shape approaches that of a circle. In the subsequent stripping, however, the proportion will be much less, as the shape of the area stripped will generally be that of a long and narrow rectangle, and only the end slopes would have to be considered, or if a square area is uncovered in the first place, only the slopes of two sides would enter in the subsequent stripping estimate. Therefore, if nothing has been overlooked, it is safe to state that the following proposition, offered at the inaugural meeting of this institute by Mr. Larsson, is correct for the Mesabi, namely:

"That where the volume of ore to be uncovered is equal to, or greater than the volume of surface to be removed, it will pay to strip."

The loss in good underground mining is liable to be anywhere from ten to twenty per cent, and therefore from eleven to forty-three per cent of the profit per ton, if mined in open pit, should be added to the cost of underground mining when comparing the two methods. Owing to the uncertainty of this item, however, it has been neglected. If in the future the cost of stripping can be reduced the economical limit of open-pit mining will be increased, and it will not be surprising if, at no distant day, two cubic yards of covering are removed for one of ore, when the ore is hard, of good quality, and marketable at a respectable profit.

COMMUNICATION ON THE COST OF CRUSHING HARD HEMATITES.

(*Read by the Secretary.*)

I had expected to read at this meeting a paper by Mr. H. J. Wessinger, master mechanic of the Minnesota Iron Company, on crushers, treating of their general construction, and particularly of those points which he believes have not received proper attention, but other matters have delayed its preparation. The following data as to the cost per ton of ore crushed may be of interest: The crushers are charged under these heads, supplies, oils, lumber, fuel, shop labor and material, and pay roll. In the last account are included the men who pass the material through the crushers, make changes and repairs, engineers, and a portion of the firemens' wages, but not the tramming to or from the crushers.

During the three months ending January 1, last, 110,477 tons of ore passed through the crushers, costing for supplies $5,025, or 4.54 cents per ton, and grouping the other accounts in one, $3,718.47, or 3.36 cents per ton; total, $8,743.47, or 7.9 cents per ton.

We have no means of determining what per cent of the ore needs to be crushed, but assuming it to be sixty per cent, the cost was 13.19 cents per ton.

The company has two crusher plants. At each is a 14"x36" Reynolds' Corliss engine and three 28"x30" crushers; some made by S. E. Cleaves & Son, of Hancock, Mich., and others by the Lake Shore Iron Works, Marquette, Mich. All are of the Blake design. One engine has developed 125 horse power. With 100 horse power an average pressure of about 170 tons can be delivered opposite the toggle.

Wearing faces of chilled iron, tank steel, armor plate (not Harveyized) and cast steel have been tried, the last giving twice the service of any other. A trial of finished armor plate would have been made but the manufacturers were unable to promise a perfect fit. and assured us that after being treated we could not touch the metal with tools.

SERIAL